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PERSONAL WATERCRAFT AND OFF-POWER STEERING SYSTEM FOR A PERSONAL WATERCRAFT

The present application claims priority to U.S. Provisional Appln. of Simard, Ser. No. 60/180,223, filed February 4, 2000, the entirety of which is hereby incorporated into the present application by reference.

1. Field of the Invention

The present invention relates generally to a steering control mechanism for a personal watercraft ("PWC"). More specifically, the invention concerns a control system that assists in steering a PWC when the jet pump pressure falls below a predetermined threshold.

2. Description of Related Art

Typically, PWCs are propelled by a jet propulsion system that directs a flow of water through a nozzle (or venturi) at the rear of the craft. The nozzle is mounted on the rear of the craft and pivots such that the flow of water may be directed between the port and starboard sides within a predetermined range of motion. The direction of the nozzle is controlled from the helm of the PWC, which is controlled by the PWC user. For example, when the user chooses to make a starboard-side turn, he turns the helm to clockwise. This causes the nozzle to be directed to the starboard side of the PWC so that the flow of water will effect a starboard turn. In the conventional PWC, the flow of water from the nozzle is primarily used to turn the watercraft.

At low speeds (i.e., when the user stops applying the throttle), the motor speed (measured in revolutions per minute or RPMs) drops, slowing or stopping the flow of water through the nozzle at the rear of the watercraft and, therefore, reducing the water pressure in the nozzle. This is known as an "off-throttle" situation. Pump pressure will also be reduced if the user stops the engine by pulling the safety lanyard or pressing the engine kill switch. The same thing would occur in cases of engine failure (i.e., no fuel, ignition problems, etc.) and jet pump failure (i.e., rotor or intake jam, cavitation, etc.). These are known as "off-power" situations. For simplicity,

throughout this application, the term "off-power" will also include "off-throttle" situations, since both situations have the same effect on pump pressure.

Since the jet flow of water causes the vehicle to turn, when the flow is slowed or stopped, steering becomes less effective. As a result, a need has developed to improve the steerability of PWCs under circumstances where the pump pressure has decreased below a predetermined threshold.

One example of a prior art system is shown in U.S. Patent 3,159,134 to Winnen, which provides a system where vertical flaps are positioned at the rear of the watercraft on either side of the hull. In this system, when travelling at slow speeds, where the jet flow through the propulsion system provides minimal steering for the watercraft, the side flaps pivot with a flap bar into the water flow to improve steering control.

A system similar to Winnen is schematically represented by Fig. 25, which shows a watercraft 1100 having a helm 1114. Flaps 1116a, 1116b are attached to the sides of the hull via flap bar 1128a, 1128b at a front edge. Two telescoping linking elements 1150a, 1150b are attached to arms 1151a and 1151b, respectively, at one end and to the respective flap bars 1128a, 1128b at the other end, respectively. Arms 1151a, 1151b, are attached to partially toothed gears 1152a, 1152b, respectively. Gear 1160 is positioned between gears 1152a, and 1152b to engage them. Gear 1160 is itself operated, through linking element 1165 and steering vane 1170, by helm 1114. Fig. 19 illustrates the operation of the flaps when the watercraft is turning to the right, or starboard, direction.

Because the gears 1152a, 1152b are only partially toothed, when attempting a starboard turn, only gear 1152b will be engaged by gear 1160. Therefore, the left flap 1116a does not move but, rather, stays in a parallel position to the outer surface of the hull of the PWC 1100. Thus, in this configuration, the right flap 1116b is the only flap in an operating position to assist in the steering of the watercraft 1100.

While the steering system of Winnen, represented in Fig. 25, provides improved steering control, the system suffers from certain deficiencies. First, steering is difficult. When the flap bars 1128 are located at the front portion of the flaps 1116 (as shown), the user must expend considerable effort to force the flaps 1116a, 1116b

out into the flow of water. Second, the force needed to force flaps 1116a, 1116b into the water stream causes considerable stress to be applied to the internal steering cabling system that may cause the cabling system to weaken to the point of failure. Third, only one flap 1116b is used at any given moment to assist in low speed steering. Thus, the steering system shown in Fig. 19 is difficult to use, applies unacceptable stresses to the internal steering system, and relies on only half of the steering flaps to effectuate a low speed turn.

Such a system could be modified to use simpler telescoping linking elements to attach the steering vane 1170 to flaps 1116, instead of the more complex gear arrangement. Unfortunately, the sliding nature of the telescoping linking elements makes these structures susceptible to seizing up in salt water.

For at least these reasons, a need has developed for an off-power steering system that is more effective in steering a PWC when the pump pressure has fallen below a predetermined threshold.

SUMMARY OF THE INVENTION

A PWC according to this invention has an improved system comprising at least one flap or rudder placed at a side of the hull. This invention relates to the design and operation of generally vertical rudders positioned on the port and starboard sides of the PWC hull that assist in steering the PWC when the pump pressure falls below the predetermined threshold. In addition, the rudders can be vertically adjustable to provide even greater assistance in steering control when the pump pressure falls below the predetermined threshold.

Therefore, one aspect of embodiments of this invention provides an off-power steering system in which the rudders and linking elements assist the driver in steering a PWC in off-power situations without causing undue stress on the driver or the helm control steering mechanisms.

Another aspect of the present invention provides a PWC with simplified linking elements that do not seize up in salt water, and are less complex than those known in the prior art.

An additional aspect of the present invention provides an off-power steering mechanism that automatically raises and lowers vertical rudders according to the water flow pressure within the venturi or flow nozzle.

A further aspect of the present invention can make off-power steering more efficient by using both rudders simultaneously and in tandem to assist in steering.

Embodiments of the present invention also provide an improved rudder that can be used with an off-power steering system.

An additional embodiment of the present invention provides an off-power steering mechanism kit to retrofit a PWC that was not manufactured with such a mechanism.

These and other aspects of the present invention will become apparent to those skilled in the art upon reading the following disclosure. The present invention preferably provides a rudder system wherein a rudder is positioned near the stern and on each side of the hull of a PWC. The preferred embodiment utilizes a pair of vertically movable rudders operating in tandem during steering.

The invention can provide a steering system that is simpler to build and easier to steer. The system can automatically lower the vertical rudders when off-power steering is necessary and can automatically raise the vertical rudders when off-power steering is not needed.

The rudders according to this invention are spaced a predetermined distance from the hull and pivot from a position inwardly from an edge of the rudder to enable water to flow on an inside surface and an outside surface. Other embodiments of the invention are described below.

It is contemplated that a number of equivalent structures may be used to provide the system and functionality described herein. It would be readily apparent to one of ordinary skill in the art to modify this invention, especially in view of other sources of information, to arrive at such equivalent structures.

BRIEF DESCRIPTION OF THE DRAWINGS

An understanding of the various embodiments of the invention may be gained by virtue of the following figures, of which like elements in various figures will have common reference numbers, and wherein:

Figure 1 illustrates a top view in partial section of a first embodiment of the present invention with the flaps in the inactive position;

Figure 2 illustrates the first embodiment of the present invention with the starboard flap in an operable position;

Figure 3 is a perspective view of the starboard flap in an operable position;

Figure 4 illustrates a top schematic view of a second embodiment of the present invention;

Figure 5 illustrates a back view in partial section of a third embodiment of the present invention;

Figure 6 illustrates a side view in partial section of the third embodiment of the present invention;

Figure 7 illustrates the top view in partial section of the starboard rudder of a third embodiment of the present invention;

Figure 8 illustrates a back view in partial section of a fourth embodiment of the present invention;

Figure 9 illustrates a side view in partial section of the fourth embodiment of the present invention;

Figure 10 illustrates a back view in partial section of a fifth embodiment of the present invention;

Figure 11 illustrates a schematic top view in partial section of a sixth embodiment of the present invention;

Figure 12 illustrates a back view in partial section of the sixth embodiment of the present invention;

Figure 13 illustrates a back view in partial section of a variation of the sixth embodiment of the present invention with a modified rudder;

Figures 14a through 14c illustrate various partial perspective views of the rudder according to the sixth embodiment of the present invention;

Figures 15a through 15c illustrate a seventh embodiment of the present invention from a top view;

Figure 16 illustrates the seventh embodiment of the present invention from a partial side view;

Figure 17 shows a chart comparing the various distances necessary to stop and turn a PWC operating with and without flaps;

Figure 18 is a top view of the port half of a PWC with the deck removed and a portion of the tunnel cut away, the view illustrating an eight embodiment of the invention;

Figure 19 is a partial sectional view taken along line 21-21 in Figure 18;

Figure 20 is an elevated view of a piston/bracket unit used in the eighth embodiment of the invention;

Figure 21 is a cross-sectional view taken along line A-A of Figure 22;

Figure 22 is a perspective view of a rudder used in the eighth embodiment of the invention;

Figure 23 is a partial cross-sectional view showing the interconnection between the rudder and the rod through the opening in the hull wall in the eighth embodiment;

Figure 24 is a cross-sectional view of a T-connector used in the eighth embodiment of the invention; and

Figure 25 shows a prior art system using gear operated flaps.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

The invention is described with reference to a PWC for purposes of illustration. However, it is to be understood that the steering and stopping systems described herein can be utilized in any watercraft, particularly those crafts that are powered by a jet propulsion system.

The first embodiment of the invention will be understood with reference to Figs. 1-3. In Fig. 1, a top view of the stern of the PWC 10 is shown. The hull 38 is only shown generally in a schematic outline to highlight the important structures of the invention. In some of the following figures, a flap or rudder system of only one side of a PWC 10 is shown for simplicity. It is to be understood that the system described for one flap is equally applicable for a flap on the other side of the craft.

The first embodiment of the invention is referred to as a "flap" system because the flaps are hinged at an edge and thus only one side of the flap deflects water to assist in steering. The prior art system to Winnen described above is an example of a flap system. The other embodiments discussed below are referred to as "rudder" systems because the rudder pivots at a point spaced a certain distance inward from the edge of the rudder. In addition, the rudders are positioned away from the surface of the hull to enable water to flow on both the inside surface and/or the outside surface of the rudder to assist in steering the PWC. The advantages of the rudder system are described in more detail below.

It is understood that a corresponding flap or rudder system is preferably placed on each side of the hull 38 shown in Fig. 1. Although the preferred two flap or rudder system is shown in the embodiments disclosed herein, a single flap or rudder can be used if desired. It is also preferable to have the flap or rudder system as far as possible from the center of gravity of the PWC (i.e., near the transom) while still being located in the high pressure relative flow generated by travel of the hull through the water in order to have the greatest possible moment arm for the forces applied by the flap or rudder. This will provide more efficient steering. Accordingly, where

specific details regarding the off-power steering structure are provided for only one side, the details are applicable to a corresponding structure on the opposite side. Additionally, while the flap or rudder is shown as being attached to a side of the hull, it is also possible to attach a flap or rudder in accordance with this invention to the stern.

The flap system according to the first embodiment of the present invention provides a steering system in which the flaps 216a, 216b each rotate around two different axes instead of just one. The object of this embodiment is to position the flaps deeper in the water to increase their steering efficiency while minimizing the contact with the water to minimize drag when the flaps are not required for steering.

The flap systems 40a, 40b comprise the flaps 216a, 216b and double-ended ball joints 43a, 43b that attach the flaps 216a, 216b to the hull 38. Flap system 40a is on the port side, and flap system 40b is on the starboard side. The double-ended ball joints 43a, 43b comprise rods 42a, 42b connected 48a, 48b to the hull 38. Any known means may be used to secure the rods 42a, 42b to the hull 38, such as a nut and bolt 52a, 52b. The ball joint rods 42a, 42b are linked by connectors 46a, 46b to ears 44a, 44b. The ears 44a, 44b are connected to flaps 216a, 216b, respectively, at a top portion thereof.

As shown in Fig. 1, flap 216b has a hinged connection 50b connected to another hinged connection element 56b. The connection 56b pivots around the axis shown as B-B. This is the first of two axes around which the flap 216b rotates. The second axis of rotation for the flap 216b is provided by hinge 50b. A front flange, which is shown as 62b in Fig. 3 for the starboard side flap system of this hinge 50b, is mounted on a pivot 56b attached (by a screw for example) into the hull 38. The pivot 56b allows the vertical hinge 50b to rotate around a horizontal axis.

The flap system 40a is connected via connecting element 30a to a telescoping linking element 20. The inner structure of the telescoping linking element is referred to as 20a. The telescoping structure 20 is connected to a nozzle 18 via a pivoting element 24. The pivoting element 24 can be any structure that enables the linking structures to connect to the nozzle 18 and permits the nozzle 18 to pivot to manipulate

the flaps 216a, 216b. Nozzle 18 revolves around pivotal point 26 to steer the PWC 10 at high speeds (or with the throttle in the on position).

The venturi 32 directs the flow of water from the jet propulsion system 34 and causes the water to increase in speed as it flows through the venturi 32 to the nozzle 18. The diameter of the venturi 32 decreases to force the water to travel faster through the venturi opening. A stabilizer or sponson 12a, 12b attached to the outer surface of the hull on the port side directs the flow of water and assists in stabilizing the PWC 10. While Fig. 2 illustrates the venturi 32 and nozzle 18 as separate elements pivotally connected, it is noted that variations of the venturi/nozzle structure are considered to be within the scope of the present invention. Thus various water propulsion structures may be used to perform the functions of the venturi/nozzle combination, namely propelling water at a high rate of speed along with providing steering capabilities.

Figure 3 illustrates the starboard flap 216b in an operational position. To move flap 216b into this position, the user turns the helm (not shown) to the right or in the starboard direction. The nozzle 18 pivots around pivoting point 26 to steer the watercraft to the starboard direction. The pivotal connection 24 causes linking element 22 and telescoping insert 22a to force the flap 216b out into the flow of water (shown by the intermittent arrows). In this position, the flap 216b is connected to the hull by element 44b, which is attached to rod 42b by structure 46b. Rod 42b is connected to the hull by ball joint 52b. It is preferred that the rod 42b is stiff, so that it does not allow the connecting element 44b to pivot with respect to the rod 42b. However, it is contemplated that structures providing flexibility at this point may also be used.

The rod 42b connects through connector 48b to the hull 38 via bolt and nut arrangement 52b or some equivalent structure. The connecting element 44b, structure 46b and rod 42b firmly hold the top portion 61b of flap 216b in place and prevent it from swinging out vertically into the flow of water. While one particular arrangement is illustrated, other equivalent structures may also be provided to support the top portion 61b of the flap 216b.

When the helm 14 moves, it causes the flap 216b to assist in turning the PWC 10 into the starboard direction. In operation, the flap 216b pivots out into the water on hinge 50b in a substantially vertical direction and also pivots on bolt 54b around the axis shown by line B-B. Similarly, when the flap 216a is forced outwardly because of the pushing force coming from the telescopic linking element 20, the double ended ball joint 43a and ear 44a simultaneously push back the top of the flap 216a. By the effect of the force given by the ear 44a, the rear of the flap 216a is forced to go down deeper into the water.

In this embodiment, because telescoping linking arms 20, 22 are used, the flap 216a that is opposite the flap 216b being moved into the operative position remains parallel to the side of the hull 38 and the PWC in an inactive position. Thus, only one rudder at a time provides steering assistance.

Figure 3 is a perspective view of the flap 216b in the operative position. The flap supporting structure 44b, 42b, 46b and 48b secures the top portion of the flap 216b to prevent it from swinging outwardly or pivoting downwardly into the flow of water. As can be seen from Fig. 3, the lower portion 60b of the flap 216b pivots out further into the flow of water than the top portion illustrated by feature 61b. This causes the water to flow more easily over the top portion 61b of flap 216b, as illustrated by the intermittent arrows. Thus, in the operative position, flap 216b pivots around both the axis of hinge 50b, which axis is shown by intermittent line C-C, and the axis of bolt 54b, which is connected to hinge 50b via a connecting structure shown as 62b. The axis of rotation shown by the intermittent line B-B shows flap 216b rotated into an optimal position in the water coming from stabilizer 12b.

While the first embodiment described above uses flaps in which water will flow on only one side, the dual pivoting motion of the flap about two different axes makes it more efficient and effective than a system having a single pivoting motion, such as Wennen.

Fig. 4 illustrates the second embodiment of the present invention. This embodiment is directed to addressing the problems of (1) the lack of efficiency in using only one rudder at a time to steer, and (2) the stresses transferred to the steering components.

According to an embodiment of the invention as shown in Fig. 4, the PWC 10 has a helm 14. Stabilizers or sponsons 12a, 12b are attached at the side rear of the hull 38 and rudders 316a, 316b are connected to the hull 38 via hinges 68a, 68b. The hinges 68a, 68b connect the rudders 316a, 316b to the hull 38 a certain distance from the forward ends of the rudders 316a, 316b.

A nozzle 18 pivots around a pivoting connection 26. This pivoting connection 26 may be of any kind that is well known to those of ordinary skill in the art. The nozzle 18 is pivotally connected 24 to linking elements 66a, 66b. In the preferred embodiment, the linking elements 66a, 66b are not telescoping but are made from a single rigid structure. In this manner, they are easier to build and are more reliable than more complicated, telescoping structures known in the prior art. By using non-telescoping linking elements 66a, 66b, both rudders 316a, 316b are simultaneously moved with the rotation of the nozzle 18.

As shown in Fig. 4, when the PWC 10 is turned to the starboard direction via the helm 14, the nozzle 18 directs water flow from the jet propulsion system toward the starboard side of the PWC 10, which causes it to turn. According to the present invention, when the nozzle 18 is in this position, the port side rudder 316a is pulled inward toward the longitudinal axis of the PWC 10, shown by line A-A. Pulling the port side rudder 316a inward increases water pressure on the inside surface of rudder 316a, which assists in steering PWC 10 in the starboard direction. In addition, linking element 66b extends rudder 316b out into the water flowing off of sponson 12b. Since linking elements 66a, 66b, are pivotally connected 24 to a different portion of the nozzle 18, rudders 316a, 316b, have different turning angles. For a starboard turn, rudder 316b turns more than rudder 316a and creates a larger angle with respect to the axis A-A. Rudder 316a creates a high lift and a low drag, while rudder 316b creates a high drag and a high lift, both of which assist in steering the PWC to the starboard direction.

In addition, because hinged elements 68a, 68b are placed inward from the ends 67a, 67b of the rudders 316a, 316b, it is easier for the user to turn the steering mechanism at the helm 14 to manipulate the rudders 316a, 316b into the flow of water to assist in the off-throttle steering. Thus, this system reduces the stress both on the steering mechanisms and on the user.

Turning to Fig. 5, this figure illustrates the third embodiment of the present invention. This embodiment is directed to addressing the some of the same problems as the second embodiment above. In addition, the third embodiment also addresses the problem of the drag on the rudders when they are in the lower position in the water. If the rudders are always in a down position, they tend to produce drag in the water and slow the PWC down when it is operating at high speeds.

As shown in Fig. 5, the rudder 416b includes a plurality of fins 94 positioned to catch water when the rudder 416b is moved into an operative position. The fins 94 are angled, preferably at 15 degrees, to draw flowing water that pulls the rudder 416b down further into the water. Alternately, the fins 94 may be disposed at any angle to effect a drawing of water, preferably between about 5 and 25 degrees, but about 15 degrees is most preferred. In other words, when the fins 94 catch the water flowing off the stabilizer or sponson 12b and the bottom of the hull, this forces the rudder 416b down further into the path of the flowing water to assist in steering PWC 10.

As shown in Fig. 5, the hull 38 of the PWC 10 is connected to the deck 70 and a covering structure 72 covers the connecting point between the deck 70 and the hull 38. Bolts 88a, 88b connect a U-shaped bracket structure 76 to hull 38 to support rudder 416b and enable it to move up and down. The bracket 76 also supports the hinged movement of rudder 416b around the axis shown as D-D. The starboard linking element 66b is shown attached generally to rudder 416b. A spring 86 biases the rudder 416b into a high inactive position out of the water. The bottom 96 of rudder 416b is shown in its high position and, in phantom 97, in the lower position. Bushings 92 allow the rudder 416b to move up and down with less friction. Preferably, a lubricant 82 is used for durability. The hinge structure supported by the bracket 76 enables the rudder 416b to both move up and down to a position in or out of the water and also to rotate around axis D-D.

Figure 6 is a side view of the third embodiment of the present invention. The fins 94 are shown. It should be noted that any number of fins can be used, including just one fin, even though a plurality of fins 94 are illustrated. The linking element 66b is shown in phantom to illustrate where it connects to rudder 416b. A raised nose 98 extends from the front edge and on both sides of the rudder 416b and directs the flow of water around the rudder 416b. The nose 98 redirects the water flowing over the

rudder 416b to prevent water from engaging the fins 94 when the rudder 416b is in its inactive position. The rudder 416b rotates around axis D-D when activated by the linking member 66b. A plurality of openings 96 are located in the areas in between the fins 94 in order to allow water to flow therethrough when rudder 416b is in the operative position. Water flows over rudder 416b after being directed from the stabilizer 12b and the bottom of the hull.

When the rudder 416b opens to its operative position, water flows over the nose 98 and flows over the fins 94. The force of the water on the fins 94 causes the rudder 416b to move down and compresses the spring 86 to bring the rudder 416b into its fully lowered position in the water. Because of the openings 96 integrated between the fins 94, water applies pressure to the fins 94 to force the rudder 416b down when the rudder 416b is used to steer to the starboard direction and water flows on the outside surface of the rudder 416b. The same is true when the rudder 416b steers the PWC 10 to the port direction and water flows on the inside surface of the rudder 416b.

Figure 7 illustrates a top view of the various positions of rudder 416b (shown in Fig. 6). As discussed earlier with respect to Fig. 5, the rudder 416b is spaced away from the hull 38 of the PWC 10. Spacing the rudder 416b away from the hull 38 in addition to moving the pivotal location 74 of the rudder 416b away from the edge of the rudder 416b allows the rudder 416b to be used in steering the watercraft either to the port or the starboard direction. For example, rudder 416b can be moved into the position shown by 106. In this position, water flowing off of the stabilizer 12b will flow over the fins 94 that pull the rudder 416b down into the water. As the rudder 416b moves down into the water, more fins 94 will catch the water and thus further pull the rudder 416b into the water. The force of the water flowing over the rudder 416b will cause the PWC 10 to steer towards the starboard direction. However, if the user wants to steer the PWC 10 towards the port side, the linking element 66b will pull the rudder 416b into the position shown by the intermittent outline 108. In this position, water flowing off the stabilizer 12b and the bottom of the hull will flow across the inside surface of the rudder 416b.

The fins 94 are preferably angled at approximately 15° to the horizontal. Other angles may be used also (preferably between 5 and 25 degrees), as long as the

fins 94 operate to pull the rudder 416b into the water against the bias of spring 86 so that the rudder operates to assist in the off-power steering of the PWC 10.

Figure 8 illustrates the fourth embodiment of the present invention. According to this embodiment, the rudder 516b is attached to the hull 38 via bolts 88a, 88b. Other means of attachment may also be employed and will be apparent to those of ordinary skill in the art. A spring 86 biases the rudder 516b in an upward position 124. In this manner, the rudder 516b will normally be in its upward position 124. However, once the rudder 516b rotates out into the flow of water, an articulated, rotatable mini flap 112 positioned on the rudder 516b will assist in pulling the rudder 516b into the water. When the rudder rotates, the mini flap 112 rotates around axis F-F as shown in Fig. 9.

The water flowing over mini flap 112 as the rudder 516b is in its operable position causes the mini flap 112 to rotate around axis F-F. A slider 113 attaches element 114, 122 to the top of the mini flap 112 and forces the top of the mini flap 112 to rotate inward when the rudder 516b is opened into an operable position in the flow of water. Rotating the mini flap 112 to a certain position in connection with water flowing over the mini flap 112 forces the rudder 516b down against the bias of spring 86 and thus pulls the rudder 516b down into the water. In this operative position, the rudder 516b will be more effective in helping to direct and steer the PWC 10 in off-power conditions.

Figure 10 shows a fifth embodiment of the present invention and is similar to other embodiments except that the spring 86 biases the rudder 616b down into the water rather than up, as was discussed previously. The rudder is labeled in Fig. 10 as 616b, but in this and other embodiments, the various illustrations of the rudder systems are interchangeable. For example, the basic rudders 316a, 316b, shown in Fig. 4, or the variable surface rudders 716a, 716b, shown in Figs. 14a-14c, may be interchangeably used with the various embodiments of the invention.

In the fifth embodiment of the invention, structural elements 130 shown in Fig. 10 connect the rudder 616b to a rod 129 and operate to move the rudder 616b up or down, also referred to as vertical movement. It is to be understood that any reference to movement in a relative up or down position, especially with respect to the

surface of the water, is considered herein to be vertical movement even though it may be at an angle to true vertical.

The rudder 616b may be positioned high 132 or low and in water 128. The structural elements 130 enable the rudder 616b to pivot around an axis D-D and to move up and down into the upper and lower positions as previously discussed. This embodiment is useful because the rudder 616b can be positioned or biased in the water but can be moved out of the water if the watercraft strikes a submerged object or is operating at high speeds, which can cause the hull to ride higher in the water. The rudder configuration of Fig. 10 is preferably used with the clutch system disclosed below with reference to Figs. 15a-15c and 16.

Figure 11 shows the sixth embodiment of the present invention. As shown in Fig. 11, water lines 136a and 136b are connected to holes 135a, 135b within the venturi 32. The water lines 136a, 136b respectively extend from holes 135a, 135b in the venturi 32 through the linking elements 66a, 66b and out near the rudders 616a, 616b. The rudders 616a, 616b are connected to the hull via hinged elements 140a, 140b and the linking elements 66a, 66b connect the nozzle 18 to rudders 616a, 616b via hinged elements 30a, 30b. The rudders 616a, 616b, are preferably angled inwardly, as shown in Figure 11, to provide additional deceleration when they are in a lowered operable position. This angle can vary based on the vertical positioning of the rudders. The water lines 136a, 136b pass through linking elements 66a, 66b. However, other means of connecting the water lines to the hinged portions 140a, 140b are also contemplated, including passing the water lines 136a, 136b through the hull 38 at the stern or attaching them on the outside surface of the hull.

This embodiment obviates the need for a clutch.

Figure 12 provides another view of the preferred embodiment of the present invention. It shows a rear view of the starboard side rudder 616b. The connection of the linking element 66b to the rudder 616b is not shown in order to view the hinge structure of the invention. The hinged portion 140b comprises a rod 118, a hinge 86, and a water cylinder 146. The water line 136b exits from a hollow portion of the linking element 66b to a base portion 119 connecting an end of the water line 136b to the water cylinder 146. A bracket 76 supports the above-mentioned elements 118, 86,

146 and enables the rudder 616b to be securely attached to the hull 38 while being able to both pivot and move vertically. The internal rod 118 has a distal end 115 positioned within the water cylinder 146. The spring 86 biases the rudder 16b in a lower position 142a, 142b. The rudder 616b slides up and down the water cylinder 146 via projections 87 and 89 from the inner side of the rudder 616b. The projections 87, 89 are attached to the rear surface of the rudder 616b. Each projection 87, 89 has an opening complementary to the shape of the water cylinder 146. The projection openings enable the rudder 616b to slide up and down the outer surface of cylinder 146.

From this configuration, it can be seen that when biased by the spring 86, the rudder 616b is in a lower position such that water flowing off of the stabilizer 12b will flow across the rudder 616b if the rudder 616b is moved into the operable position. Thus, rudder 616b is capable of moving from a high position out of the water, shown by extended lines 144a and 144b, to a lower position 142a, 142b in the water to assist in steering the PWC 10.

The amount of water pressure within the water cylinder 146 controls the high or low position of the rudder 616b. The water pressure in the cylinder 146 depends on the pressure of the water flowing through the venturi 32, as shown in Fig. 11. When the throttle of the PWC is on, water is forced through the venturi 32 and nozzle 18. The water pressure in the venturi 32 varies from a front position to a more narrow rear position. The holes 135a, 135b in the venturi 32 may be located at various places but preferably are located in the high pressure region. The high pressure region is where water flows more slowly and the diameter of the venturi 32 is larger.

Furthermore, as noted earlier, the venturi/nozzle configuration may vary depending on the PWC. Accordingly, it is contemplated that water lines 135a, 135b may communicate a water pressure from a location other than the venturi 32, for example from the nozzle 18 or perhaps a speed sensor or water collection port located, for example, under the hull.

When the throttle is on and water pressure in the venturi 32 is high, water is forced through the holes 135a, 135b into the water lines 136a, 136b. Water, as shown in Fig. 12, will flow through line 136b and begin to fill the water cylinder 146. The

water in the cylinder 146 forces the distal end 115 of the piston 118 upward. The piston 118 is connected to the rudder 616b, which in turn is connected to the projections 87, 89. As the rudder 616b rises, projection 87 contacts and compresses the spring 86 against the spring bias. The rudder 616b moves into the higher position shown by 144a and 144b.

Water in the venturi 32 travels relatively slowly through the wider region 33 of the venturi 32. In this region, although the water travels more slowly, the water pressure is higher. Holes 135a, 135b are positioned preferably in this high pressure region 33 of the venturi 32. The venturi 32 narrows as it nears the exit portion 35. As the venturi 32 narrows to this region 35, water travels more quickly and the water pressure decreases. Water then is expelled out of the venturi 32 into the nozzle 18 that pivots around pivotal point 26 in order to propel and steer the PWC 10.

In this embodiment, water hoses 136a, 136b are respectively attached to holes 135a, 135b. When water is flowing through the venturi 32 at a high rate of speed and the pressure in region 33 of the venturi 32 is high, water is forced out through the holes 135a, 135b into the respective water lines 136a, 136b. Linking elements 66a, 66b, as in previous embodiments, are connected via a pivotal point 24 to the nozzle 18. Pivotal connecting elements 30a, 30b connect the linking elements 66a, 66b to the respective rudders 616a, 616b. On the starboard side, linking element 66b connects via pivotal point 30b to the nozzle 18 and to the rudder 616b. The linking elements 66a, 66b may be hollow to allow the water lines 136a, 136b to be inserted therein and thus brought through the linking elements 66a, 66b near the rudders 616a, 616b.

On the port side, water line 136a extends from the distal end of the linking element 66a and connects to the hinged element 140a, which attaches a front region of rudder 616a to the hull 38 of the PWC 10. Similarly, on the starboard side, the water line 136b exits the distal end of linking element 66b and connects to the hinged element 140b, which connects a forward region of the starboard rudder 616b to the hull 38 of the PWC 10. (The hinged portions 140a, 140b will be shown in more detail below with reference to Fig. 12.) As shown in Fig. 11, as the water pressure increases in the venturi 32 in the high pressure region 33, water is forced into the water lines

136a, 136b and passes to the hinged elements 140a, 140b to control the raising and lowering of rudders 616a, 616b.

Preferably, the rudders 616a, 616b will be forced into their upper position when the PWC 10 has a jet pump pressure equivalent to the one obtained when the engine is operating at 4500 RPM or more under normal conditions. Below 4500 RPM, the flow of water through the venturi 32 is reduced, and the rudders 616a, 616b will drop to their lower position, for example, approximately 2 inches deep in the water.

When the rudders 616a, 616b are not needed, i.e., when steering is available through the jet propelled water traveling through the nozzle 18, the rudders 616a, 616b are positioned high in an inactive position and thus do not drag and slow down the PWC 10. However, when off-power steering is necessary because water is not flowing quickly through the venturi 32, the water pressure in lines 136a, 136b is reduced. The water in the water cylinder 146 is forced back through the water lines 136a, 136b and out the holes 135a, 135b. The rudders 616b, 616a drop down into position shown by 142a and 142b and thus come into contact with water flowing off of stabilizers12a, 12b to allow the user to steer the PWC 10 at low speeds where such steering assistance is necessary.

According to the present invention, off-power steering can be more efficiently accomplished at low speeds in which the rudders 616a, 616b will automatically drop from a higher position to a lower position into the water once the water pressure in the venturi 32 reaches a certain level.

The preferred embodiment utilizes the pivotal arrangement of the rudders shown in Fig. 4, which is more efficient because both rudders 316a, 316b are used in tandem. As is shown in Fig. 4, pivotal points 68a, 68b are not located at the front portions 67a, 67b of the rudders 316a, 316b. Because the pivotal points 68a, 68b are positioned a certain distance from ends 67a, 67b, the force necessary to move rudders 316a, 316b into the flow of water off of stabilizers 12a, 12b and the bottom of the hull is reduced. In addition to reducing the load on the rudder steering components, the water flow over the rudder is more balanced on each side of the hinge 68a, 68b.

As shown and discussed earlier, the nozzle 18 directs water flowing from the jet propulsion system in certain directions in order to steer the PWC 10. In the second embodiment shown in Fig. 4, linking elements 66a, 66b are not telescoping as was shown in the previous embodiment but comprise a single rigid structure. The pivotal elements 24 connect linking elements 66a, 66b respectively to nozzle 18 allowing the nozzle 18 to pivot when actuated by the steering mechanism at the helm 14. The linking elements 66a, 66b are respectively connected, via pivotal points 30a, 30b, to the rudders 316a, 316b.

In the second embodiment, when the user steers the watercraft, for example, towards the right or starboard direction, the linking element 66a pulls the rear portion of rudder 316a inward towards the hull 38 and thus positions the rudder 316a to allow water to flow on the inner surface of rudder 316a. The water flowing off of stabilizer 12a thus passes over and is redirected by the inside surface of rudder 316a. When turning to the starboard side, pivotal element 24 causes the linking element 66b to force rudder 316b out into the flow of water coming off of stabilizer 12b and the bottom of the hull.

In order to accomplish the result of using both rudders 316a and 316b in off-power steering, the rudders 316a, 316b are spaced farther apart from the hull surface 38 than as shown in Fig. 1. As an example, the rudders 316a, 316b preferably may be spaced about 1.5 inches (about 38.1 mm) from the hull 38. This distance will vary depending on the components used and other factors known to those of skill in the art. For example, the distance may be selected from within a range between about 0.5 and 2 inches (about 38.1- 50.8 mm) from the hull. However, any suitable range may be selected based on the configurations and dimensions of the hull.

Both rudders 316a, 316b participate in the off-power steering of the PWC 10. In addition, the linking elements 66a, 66b do not need to be telescoping and thus do not have the susceptibility of seizing up or ceasing to operate in the telescoping fashion when used in salt water. Furthermore, single-structure linking elements 66a, 66b are more cost effective and easier to maintain than their telescoping counterparts. In addition, the embodiment shown in Fig. 4 is easier for the user of the PWC 10 to steer because the pivotal point of rudders 316a, 316b is moved a certain distance from the ends 67a, 67b of rudders 316a, 316b. In this manner, since the fulcrum of the

pivoting point of rudders 316a, 316b is moved into a position offset from the edge of the rudder, it is much easier for the driver of the PWC 10 to steer. The linking elements 66a, 66b operate on the rear edges of rudders 316a, 316b making it easier for these rudders 316a, 316b to be forced out into the flow of water off of stabilizers 12a, 12b.

The other embodiments also address these problems discussed above, namely the lack of efficiency of the hinged rudder system, the strain of the vertical rudder system on the steering components, the drag of the rudders or rudders when they are in the lower position, and the negative aspects of the combined effect of the nozzle and rudders in a steering operation.

While Fig. 4 and Fig. 11 show the linking elements 66a, 66b and water lines 136a, 136b on the outside of the hull, other configurations are also contemplated. A double wall of fiberglass built inside the hull 38 near the stern portion may also be used to pass both the linking elements 66a, 66b and the water lines 136a, 136b to the rudders 616a, 616b. In this case, the linking elements 66a, 66b and water lines 136a, 136b would be out of sight from the rear of the PWC 10. Bushings would likely be used in the sidewalls where the linkages 66a, 66b come through the hull 38. Other configurations and structures for connecting the water lines 136a, 136b and linking elements 66a, 66b to the rudders 616a, 616b also will be recognized by those skilled in the art. For example, a tubular cover can be provided over the linking elements and water lines.

Figure 13 illustrates a variation of the sixth embodiment of the present invention. Fig. 13 shows the portside rudder 716a. The rudder 716a has a modified structure on its surface, shown generally at 151. The special structure of the rudder 716a will be described below with respect to Figs. 14a-14c. As shown in Fig. 13, piston 146 is connected to the rudder 716a using spring pins 147 at both ends of the rudder 716a. The piston 146 has a head portion 148 that is encased within a water cylinder 149. An opening 153 in the water cylinder 149 provides a fluid connection to the water line 136a which, as discussed earlier, is connected to an opening 135a in the venturi 32.

When the water pressure increases in the venturi 32, water flows in the water line 136a, through the opening 153 and into the water cylinder 149. Water is trapped within the piston region below the head 148 via a plastic O-ring 150 and the head 148 of the water cylinder 149. Water flowing into the cylinder 149 causes the piston 146 to rise and which thus lifts the rudder 716a up and out of the water.

As in earlier embodiments, a biasing spring 86 biases the rudder 716a in the down position. Further, part of the head 148 of the piston 146 has an annular surface 154. When the piston rod 146 rises due to water pressure entering the cylinder 149, the annular surface 154 will contact an annular surface of an upper bushing 156 indicated at an upward portion of the water cylinder 149, which impedes the movement of the piston 146. The spring 86 is seated on the bushing 156. A bracket 76 attaches the water cylinder 149 to the hull 38 of the PWC 10. In another region of the rudder 716a is an attachment 158a, 158b that connects the backside of rudder 716a to a rod 118. Shown in phantom, the rod 118 is surrounded by a sleeve 160 that is connected to a distal end of the linking element 66a.

In this manner, the rudder 716a can pivot around an axis extending along the piston 146 while allowing the rudder 716a to also raise up and down wherein the sleeve 160 slides over the pin 118 as the rudder 716a moves up and down according to the water pressure which is in the water line 136a. An opening in the hull 38 or in some other equivalent structure, such as a bushing 162 mounted to the hull, may allow for the support of the linking element 66a.

To avoid building up too much water pressure in the water cylinder 149, and to assist in washing and cleaning, the piston 146 and/or water cylinder 149 may leak water purposefully. At least one hole and preferably four evacuation holes (not shown) may be placed in the top region of the water cylinder 149 for this purpose.

Figures 14a through 14c are perspective views of the rudder 716a. Turning first to Fig. 14a, the surface of rudder 716a, as illustrated generally by 174, comprises various elevations that, in the preferred embodiment, peak at a point indicated by 175. Furthermore, the rudder 716a comprises a plurality of openings 172 on its face. These openings 172 are bounded by portions of the rudder 716a and also fins 170 that connect the front surface structure of the rudder to a deeper structural surface of the

rudder indicated by 173 and 177, respectively. The fins 170 also act as structural reinforcement for the rudder 716a. Angling the fins 170 will assists in moving the rudder 716a into the water, as described in the third embodiment. At a top portion of the rudder 716a is a flat extension 168 which provides a connecting means for the pivoting point 140 in order to enable the rudder 716a to pivot and assist in steering the PWC 10.

Figure 14b is another perspective view showing the openings 172 and the fins 170. The surface 174 of the rudder 716a is also shown. The openings 172 enable the rudder 716a to be turned in such a way that it may be effective in diverting water either on its outside surface 174 or on an inner surface indicated generally by 171 in Figure 14a. Thus, the rudder 716a is turned about the axis such that water flows across the inside surface 171. Water can flow through the openings 172 and across the fins 170 both to relieve pressure upon the rudder 716a, which may weaken it unnecessarily, and to allow the rudder 716a to participate in diverting enough water to assist in steering the PWC 10. However, in the same regard, if rudder 716a is turned in such a way, for example, toward the port side to assist the PWC 10 in steering to the port direction, then water will flow across the front surface of rudder 716a illustrated at 174. In such a case, water will flow over the front surface 174 and over the surface 177 and out the back of the rudder 716a. In this manner, the rudder 716a may more fully participate in steering the watercraft whether water flows across either the front surface 174 or the rear surface 171 of the rudder 716a.

The leading edge 910 of the bottom surface 900 of the rudder 716a curves upwardly to deflect floating obstacles, such as a rope, under the rudder 716a, or to help moving the rudder 716a up over solid obstacles, such as a rock, to avoid entangling or damaging the rudder 716a. The trailing edge [illegible] of the bottom surface 900 of the rudder 716a curves upwardly as well. This curve accelerates the flow of the water following the bottom surface 900, thus creating a low pressure region. This low pressure region assists in moving the rudder 716a into an operative position.

Figure 14c illustrates a top view of rudder 716a. The hinged connection 140 is illustrated as the point around which the rudder pivots. Fig. 14c provides a general understanding of the shape of the top surface 168. The top surface 168 preferably has an airfoil shape to increase the efficiency of the rudder 716a when turning. However,

this shape shown in Figs. 14a through 14c is not necessarily meant to be limiting but is only exemplary of possible configurations and locations of cavities or openings 172 within the rudder 716a that help direct water over surfaces or through the rudder where necessary. It is contemplated that other configurations may be available or used in connection with these general ideas.

Figures 15a through 15c illustrate a seventh embodiment of the present invention. As in earlier embodiments, the rudders 816a and 816b are connected via hinged portions 68a and 68b to the hull 38 at a location spaced a certain distance from the end of the rudders 816a, 816b. This offset position, which places the fulcrum away from the end of the rudders 816a, 816b, makes it easier to force the rudders 816a, 816b out into the flow of water. Figures 15a through 15c illustrate a clutch mechanism in which both rudders 816a, 816b may be moved simultaneously in order to assist in steering during throttle operation. Furthermore, in this embodiment, using the clutch system enables both rudders 816a and 816b to remain inoperative when they are not needed for steering purposes. The rudders 816a, 816b may be any of the rudder embodiments disclosed herein or other configurations.

As shown in Fig. 15a, a slider 186 includes a slot opening 192. While slider 186 and the clutch mechanism are shown on top of the nozzle, the clutch system could also be below the nozzle. The slot opening 192 includes two regions 194, 196 for receiving a locking pin 188. When the pin 188 is in the first unlocked region 196, the pin 188 slides and does not engage the slider 186. The second locking region 194, is discussed below. The clutch system further comprises a pair of brackets 180a, 180b connected to pivotal attachments 182a, 182b to the nozzle 18. Bracket 180a is attached at one end by pivotal attachment 182a to the nozzle 18 and, at the other end, is attached to linking element 66a via a pivotal attachment at 184a. Bracket 180b is attached to the nozzle 18 at pivotal attachment 182b at one end and is attached to linking element 66b at pivotal attachment 184b at the other end.

The locking pin 188 is attached to a transverse bracket 183 which is connected at one end to pivotal point 184a and at the other end of pivotal point 184b which, as previously discussed, are respectively attached to brackets 180a, 180b and linking elements 66a, 66b. When the locking pin 188 is not engaged with the slider 186, or the locking pin 188 is in the non-engaging portion of the opening 196, as illustrated in

Figs. 15a and 15b, movement of the nozzle 18 will not cause the rudders 816a, 816b to move.

The non-engaged mode of operation is further illustrated in Fig. 15b. In Fig. 15b, the pin or bolt 188 is allowed to slide through the slider opening 196 as the nozzle 18 is moved back and forth. As the pin 188 slides through the lower region of opening 196, it does not engage the transverse element 183 in order to affect the motion of movement of rudder 816a, 816b. In this non-engaging mode, the slider 186 does not engage the pin 188 and is not set within the cover 190. The brackets 180a, 180b prevent the linking elements 66a, 66b from moving the rudders 816a, 816b into inactive or inoperative positions. In this mode, the nozzle 18 moves left or right without moving the rudders 816a, 816b since locking pin 188 is not engaged in the engaging portion 194 of the slot opening 192 within the slider 186. This is because the slider 186 moves freely to the left and right in connection with the movement of the nozzle 18, but does not engage the locking pin 188 and thus does not engage the linking elements or the movement thereof in order to actuate the rudders 816a, 816b.

Figure 15c illustrates the locking pin 188 engaged with the cavity 194. When the transverse element 183 is engaged via locking pin 188 to the slider 186, it enables the linking elements 66a, 66b to move as the nozzle 18 rotates around pivotal point 26. In this manner, both rudders 816a, 816b simultaneously rotate around their respective hinges 68a, 68b since they are connected to the non-telescoping structures of the linking elements 66a, 66b.

Figure 16 illustrates a side view of the clutch mechanism disclosed in Figs. 15a through 15c. A nozzle rudder 204 is positioned inside the nozzle 18 and is approximately 3mm wide. The linking element 66a and pivotal connecting portion 184a are connected and stacked with the bracket 180a and transverse connecting element 183. Also, the cover portion 190 covers a portion of the slider 186 in the linked position. In addition, the nozzle rudder 204 is pivotally attached to the nozzle 18 at a pivot point 206 and an extension flange 208 extends from the top of the nozzle rudder 204. A spring 200 is attached at one end to the flange 208 and biases the rudder 204 down in the water. When the speed of the water, i.e., the dynamic pressure of the water, is high enough, the water causes the rudder 204 to rotate around pivotal axis 206. Preferably, the rudder 204 would be fully positioned at a dynamic

pressure corresponding to a motor speed of between about 3500 and 5500 RPM under normal operating conditions. Most preferably, the locking pin 188 engages the opening 192 when the dynamic pressure corresponds to a motor speed of about 4500 RPM under normal operating conditions.

Spring 200 is connected at its other end via a flange 210 to cover 190. Cover 190 is attached to the nozzle 18 through a screw or similar attachment means 202. When water flows through the nozzle 18 at high speeds, the water will force the nozzle lever 204 rearward in the same direction as the water flow. The effect of the flow of water through the nozzle 18 causes the nozzle lever 204 to pivot about point 206 and to draw forward the slider 186 thus causing the pin 188 to engage the slider opening 196. This prevents the linking element 66a, 66b from causing the rudders 816a, 816b to pivot out into the path of the water and thus participate in steering the PWC 10.

The locking pin 188 is mounted on the transversal link 183 that is connected at both ends to the linking elements 184a, 184b, respectively. The transversal link 183 connects the left and right rudders 816a, 816b and linkage elements 66a, 66b such that when the locking pin 188 is not engaged, the locking pin 188 is free to move sideways back and forth without manipulating the rudders 816a, 816b. To engage the rudders 816a, 816b, the spring 200 stiffness can be adjusted so that the nozzle rudder 204 will move into its fully down position when the water pressure corresponds to the speed of the motor reaching 2500 RPM under normal operating conditions. When the nozzle rudder 204 is down, the slider 186 is in its rear position and the locking pin 188 is engaged in the locking portion 194 of slot opening 192.

The shape of the slot opening 192 can be modified or adjusted to vary the corresponding motor speed range (RPMs) in which the rudders 816a, 816b are engaged by the clutch mechanism. Preferably, the locking pin 188 engages the locking portion 194 of the opening 192 when the corresponding motor speed is between 3000 and 4500 RPM. It is also contemplated that the shape of the slot opening 192 could be inverted to engage locking pin 188 at pressures corresponding to high motor speeds only. Such a clutch mechanism could also be used in systems other than off-power steering systems, such as a trimming system or any other suitable system known to one skilled in the art.

Figure 17 illustrates results of fields tests performed on PWCs and shows the effect of flaps/rudders or no flaps/rudders and of either driving straight or turning while decelerating the PWC. The tests were performed using the rudder configuration shown in Figs. 14 and 18. The speed and miles per hour are on the vertical axes and the distance in feet it took the PWC to decelerate from a speed of around 58 mph down to 10 mph are on the horizontal axes. Line A illustrates no rudders being used and the PWC traveling in a straight line. In this case, approximately 300 feet were required for the PWC to slow from a speed of 58 mph to 10 mph. Line B shows that it took 270 feet for a PWC to slow from 58 mph to 10 mph when no rudders were used and the PWC was turned at the same time as it was decelerating.

Line C illustrates the effect of having two rudders starting in a raised position and activated to lower into the water and turning the PWC while slowing. In this case, it took approximately 160 feet for the PWC to slow from a speed of 58 mph to 10 mph. This is similar to the stopping distance of a car. Figure 17 illustrates the great advantages of using rudders according to the present invention in order to assist in decelerating the PWC.

Figures 18-24 show an eighth embodiment of the invention. In this eighth embodiment, the PWC 10 has an alternative construction for connecting the nozzle 900 to the rudders. Figure 18 is a top view showing only one lateral half of the PWC 10 and with the deck removed. Also, the rearward portion of the tunnel 902 is cut away and the nozzle therein is shown schematically at 904. In Figure 18, a U-shaped bracket 906, a generally vertically extending flexible member 908 made from Delrin®, a through-hull fitting 909, a rigid stainless steel rod 910 housed in a rubber tube 912, an X-shaped bracket 914, a fluid T-connector 916, and a pair of rubber hoses 918, 920 are all shown.

The nozzle 904 is pivotally mounted for directing the pressurized stream of water to provide steering in the same manner as described above or in any other suitable manner. The U-shaped bracket has a laterally extending portion 922 with a pair of vertically extending portions 924, 926 on opposing ends thereof. The center of the laterally extending portion 922 is pivotally connected to the underside of the nozzle so that pivotal movement of the nozzle shifts the U-shaped member 906 generally laterally. Specifically, pivoting the nozzle 904 clockwise shifts the U-

shaped member 906 laterally to the port side of the PWC 10. Likewise, pivoting the nozzle 904 counterclockwise shifts the U-shaped member 906 laterally to the starboard side of the PWC 10. The U-shaped member is pivotally connected to the underside of the nozzle 904 by a single bolt 928 inserted through a bore in the general center of the laterally extending portion 906. A sleeve 930 is received around the bolt 928 and abuts against the underside of the nozzle 904. The U-shaped member 906 can slide vertically along the exterior of the sleeve 930 so that vertical force components applied to the U-shaped member 906 are not transmitted directly to the nozzle 904.

Figure 19 shows the manner in which the U-shaped member 906 is connected to flexible member 908 and the manner in which the flexible member 908 is connected to rod 910. An identical construction for interconnecting these elements is provided on the starboard side of the U-shaped member 906. The vertical portion 924 of the U-shaped member 906 has a bore therethrough and the lower end portion of the flexible member 908 has a bore therethrough. These bores are aligned and a threaded bolt 932 is inserted through the aligned bores. The bore in the flexible member 908 is counterbored and a wear resistant washer is received in the bore adjacent the head of the bolt 932 to facilitate pivotal movement. A nut 934 is threaded onto the bolt 932 and tightened. This pivotally connects the flexible member 908 to the U-shaped member 906. The pivotal connection allows for some relative movement to occur between the U-shaped member 906 and the flexible member 908.

The flexible member 908 has a perpendicularly extending portion 936 at the upper end thereof. Portion 936 has a threaded bore (not shown) formed therein. The sleeve 912 is inserted into a hole in the vertical wall of the tunnel 902 and has a flange 942 extending radially therefrom inside the tunnel 902. The flange 942 has an annular sealing ridge 944. The fitting 909 is inserted from the tunnel interior into the open end of sleeve 912 and is secured to the tunnel wall by a series of bolts 938. The fitting 909 holds the flange 942 of tube 912 against the tunnel wall so that the ridge 944 is provides a seal to substantially prevent water to leak from the tunnel interior into the main hull cavity. The fitting 909 has a bore 940 extending therethrough. The perpendicular portion 936 of the flexible member extends partially into the bore 940 from the tunnel interior. The rod 910 extends through the tube 912, into the bore 940,

and is received in the bore formed in the perpendicular portion of the flexible member 936. The end of the rod 910 is threaded so that the rod 910 is retained in the perpendicular portion's bore by threaded engagement. A low friction tape, such as conventional masking tape, is wrapped around the threads of the rod so that some rotational play can occur between the rod 910 and the flexible member 908. By this connection, as the U-shaped member 906 moves laterally during the pivotal movement of the nozzle 904, the rod 910 will be pushed/pulled within the sleeve 912, as dictated by the movement of the nozzle 904 and the U-shaped member 906.

Figures 20 and 21 show an integrated piston/bracket unit 950, which comprises a piston assembly 952 and a bracket 954. The bracket 954 has four mounting bores 956, a piston fluid port 955 extending from the inner surface thereof, and a rod receiving portion 957 extending from the inner surface thereof. Four bores corresponding to mounting bores 956 are formed on the outer wall of the hull and the X-bracket 914 has another set of four corresponding mounting bores. The X-bracket also has a center mounting bore and the hull has a corresponding mounting bore centered with respect to its other four bores. To connect the brackets 914 and 954 to the hull, the X-bracket 914 is placed on the inner surface of the hull with its mounting bores aligned with the hull bores and a bolt is inserted through the X-bracket center bore and the hull center bore to initially mount the bracket 914 with the other four hull bores and the other four bracket bores aligned. The bracket 954 (along with the entire unit 950) is then placed on the exterior surface of the hull with the mounting bores aligned with the four hull bores and the four X-bracket bores. Four bolts 958 (Fig. 18) are then inserted through these aligned bores to attach the brackets 914 and 954 to the hull wall. A soft rubber sealing member 959 is provided on the inner surface of the bracket 954 to reduce the chances of any water from leaking into the hull through the hull bores. Two additional bores are provided in the hull wall for connecting the rod 910 to the rudder 960 and the hose 918 to the piston assembly 952, including one bore spaced rearwardly from the X-bracket 914 and one bore spaced below from the X-bracket 914. The piston fluid port 955 extends through the bore below the X-bracket 914 into the interior of the hull for connection to hose 918. The hull bore spaced rearwardly from the X-bracket 914 has the rod receiving portion 957 extends therethrough when the unit 950 is mounted.

Figure 22 shows a rudder 960. The rudder 960 has a construction generally similar to those discussed above and thus it will not be discussed in detail, with the exception of a brief discussion of how it attaches to the piston/bracket unit 950. The rudder 960 has a pair of tabs 962, 964 extending laterally inwardly from the inner surface thereof. The tabs 962, 964 have bores 966, 968. The upper and lower walls have pivot mounting bores 970, 972. The lower bore 972 has an interlocking projection 974 extending inwardly therefrom. The upper wall has a laterally extending bore 976 that opens at an inner end to bore 970 and at its outer end to the exterior of the rudder 960. The manner of connection will be discussed after detailing the piston assembly 952 and its operation.

Referring to Fig. 21, the piston assembly 952 includes a piston rod 978 that moves generally vertically within a piston cylinder 980. A piston head 982 is fixedly mounted to the piston rod 978. Specifically, the piston head 982 has a pair of diametrically opposed bores and the rod 978 has a pair of diametrically opposed bores. A spring pin 984 is inserted through the bores to fix the piston head 982 on the rod 978. A coil spring 986 is received between the upper end of the cylinder 980 and the piston head 982 to bias the piston head downwardly. The lower end of the cylinder 980 is communicated to the pressurized water in venturi 904 by the piston fluid port 955, which is connected to hose 918, which in turn receives pressurized water from the impeller in the tunnel via T-connector 916 and its hose connected to the venturi. Thus, when the water is pressurized by impeller, water flowing into the cylinder 980 forces the piston head 982 upwardly against spring 986. As will be discussed below, because the rudder 960 is pivotally connected to the piston rod 978, it will be raised upwardly into its inoperative position. Holes (not shown) are provided in the upper end of the cylinder 980 to allow and water and/or debris that has entered the portion of the cylinder 980 above the piston head 982 to be expelled from the cylinder 980 during its upward movement.

The lower end of the cylinder 980 has a threaded opening that is sealed with a threaded plug 988. A hard plastic wear insert 990 is mounted within the plug's opening to reduce wearing on the plug 988 by the vertical movement of the piston rod 978. A pair of split sealing rings 992, 994 are mounted within the wear insert 990 to provide a seal against the rod 978. The sealing rings 992, 994 are made out of hard

plastic to prevent them from wearing down or sticking to the piston rod 978, as may happen if using a soft rubber.

The piston head 982 has an annular groove in which a pair of split sealing rings 996, 998 are received. These sealing rings 996, 998 provide a seal between the piston cylinder interior surface and the piston head 982. One on side of the piston head groove is a projection 1000 that extends downwardly into the vertical split of the upper sealing ring 996. This projection keeps the upper sealing ring 1000 from rotating. A similar projection (not shown) is provided on the other side of the piston head groove and extends upwardly into the vertical split groove of the lower sealing ring 998, which keeps the lower ring 998 from rotating. As a result of these projections, the splits in the rings 996, 998 are prevented from becoming aligned, which functions to provide for a better seal. Similar projections can be provided on wear insert to prevent rings 992, 994 from having their vertical splits aligned.

The interior of the cylinder 980 is tapered, wider at the bottom and narrower at the top. As a result, the seal between the piston head 982 and the piston interior surface is relatively tight to prevent pressure loss. However, as the head 982 travels downwardly, a gap is formed between the piston head 982 and the piston interior surface. This gap enables water underneath the piston head 982 to flow upwardly through the gap to the piston region above the piston head 982, which reduces resistance to the lowering of the piston head 982. This allows for faster movement of the rudder 960 connected to the piston rod 978 down to its operative position.

Referring to Figures 21 and 22 together, the upper end of the piston rod 978 has a bore 1004 formed therethrough. The upper end of the piston rod 978 is received in the upper pivot mounting bore 970 of the rudder 960. A threaded rod (not shown is threaded into aperture 976 and inserted into bore 1004 to lock the upper end of the piston rod 978 relative to the rudder 960. The lower end of the piston rod 978 is notched to receive projection 970 therein upon receipt in bore 972. There two connections ensure that the piston rod 978 and the rudder 960 are locked together both rotationally and axially, thus enabling the piston rod 978 and rudder 960 to move together both pivotally and vertically.

Referring to Figures 22 and 23 together, a bolt 1006 is inserted through the bores 966, 968 of tabs 962, 964. A connector 1008 positioned between the two tabs 962, 964 has a bore in which the bolt 1006 is received. The tube 912 has a radially extending flange 1010 that is positioned exteriorly of the hull wall. The flange 1010 has an annular sealing element 1012 that is engaged against the hull wall exterior to inhibit water flow into the hull. The tube 912 leads to the tunnel interior, where the presence of water is acceptable. The rod 910 protrudes from the tube 912 and is threadingly engaged within a bore in connector 1008. This establishes a mechanical connection between the rod 910 and the rudder 960 whereby movement of the rod 910 pushes the rudder inwardly and outwardly in a pivoting manner about the piston rod 978. As a result, the lateral movement of the U-shaped member 906 is able to affect corresponding pivotal movement of the rudder 960 through the flexible member 908, the rod 910 and the connector 1008.

The system on the starboard side of the PWC is identical to the one described in this ninth embodiment. Thus, the lateral movement of the U-shaped member 906 is able to affect corresponding pivotal movement of both rudders 960 through the flexible members 908, the rods 910 and the connector 1008.

Figure 24 shows a cross-section of the T-connector 916. The T-connector 916 is designed to function as a valve to let water flowing back from the piston 950 to flow into the tunnel 902 without becoming backed up. The connector 916 includes a cylinder 1020, a tubular piston rod 1022 with an integral piston head 1024 slidably mounted in the cylinder 1020, a spring 1026 biasing the piston head upwardly, and a plug 1028 closing the bottom opening of the cylinder 1020. The piston rod 1022 has a fluid passageway 1029 therethrough.

At the lower end of the piston rod 1022 is a connector 1030 that attaches to a flexible hose 1032 which in turn is connected to the venturi to enable pressurized water from in the venturi to flow upwardly through passageway 1029 and into the upper region of the cylinder 1020. This forces the piston rod 1022 and head 1024 downwardly past connection members 1034 and 1036 so that pressurized water from the venturi flows into these connection members 1034, 1036. The water is then communicated by hoses 918 to their respective piston assemblies 952 to maintain their respective rudders 960 in their inoperative positions. The hose 1032 flexes to

accommodate this downward movement. As the water pressure in the venturi drops, the spring 102 forces the piston head 1024 and rod 1022 upwardly. As the piston head 1024 passes the connectors 1034, 1036, the water in the hoses 918 can flow back into the piston region underneath the piston head 924 and out through a port 1040 formed in the cylinder 1020. This allows the piston assemblies 952 to responsively push their respective rudders 960 to their operative positions.

The T-connector is connected to the underside of the tunnel wall by bolts 1042 inserted through flanges 1044.

From the previous descriptions, a person skilled in the art should understand that it is possible to make a kit to retrofit a watercraft with an off-power steering system. The kit would include at least a linking member, a rudder and a bracket to attach the rudder to the hull. The rudder could be of any type described above, as well as any other type known. With such a kit, the standard nozzle on the watercraft to be retrofitted would require some machining to allow attachment of the linking member to it. Preferably, the kit would include a nozzle adapted for the attachment of the linking element. The kit can also include a clutch mechanism as shown in Figure 16. The linking member can be of the non-telescopic kind, in which case a flexible member and a U-shaped member, as shown in Figure 18, could be added to the kit. If the off-power steering system kit is of the type where the rudders can move vertically out of the water, the kit should include a spring. A piston and a water line could also be added to such a kit.

Although the above description contains many specific examples of the present invention, these should not be construed as limiting the scope of the invention but as merely providing illustrations of some of the presently preferred embodiments of this invention.

Additionally, this invention is not limited to PWC. For example, the vertical rudder steering systems disclosed herein may also be useful in small boats or other floatation devices other than those defined as personal watercrafts. The propulsion unit of such craft need not be a jet propulsion system but could be a regular propeller system. In such a case, the water lines between the nozzle and the flaps or rudders could be replaced with lines that provide actuating control to the rudders without

using pressurized water. For example, the lines could provide an electrical signal to electrically operate pistons or solenoids. Also, the rudders need not have any connection to the helm or the nozzle. Instead, the rudders could be operated by an actuator separate from the helm. For example, a small joystick could be used to deploy the rudders and determine the direction of steering. Thus, the scope of the invention should be determined by the appended claims and their legal equivalents rather than by the examples given.

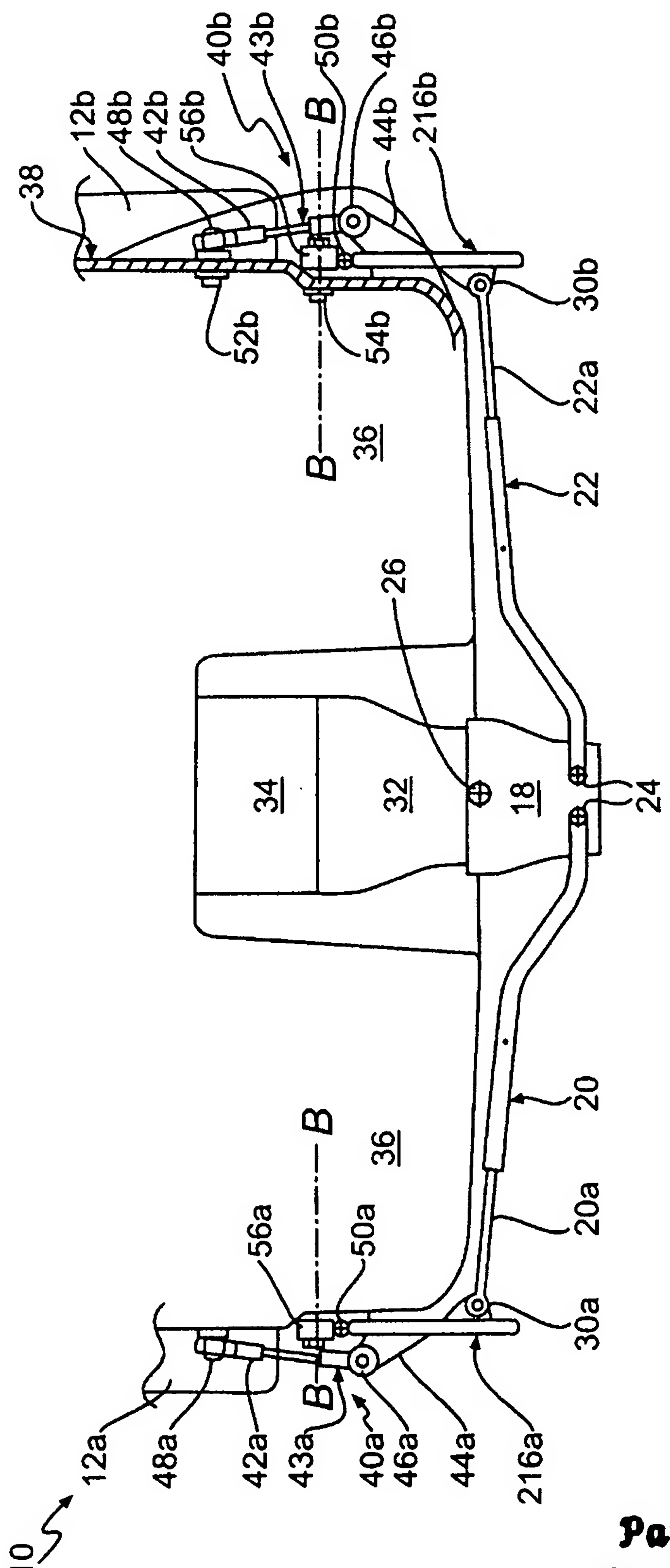

FIG. 1

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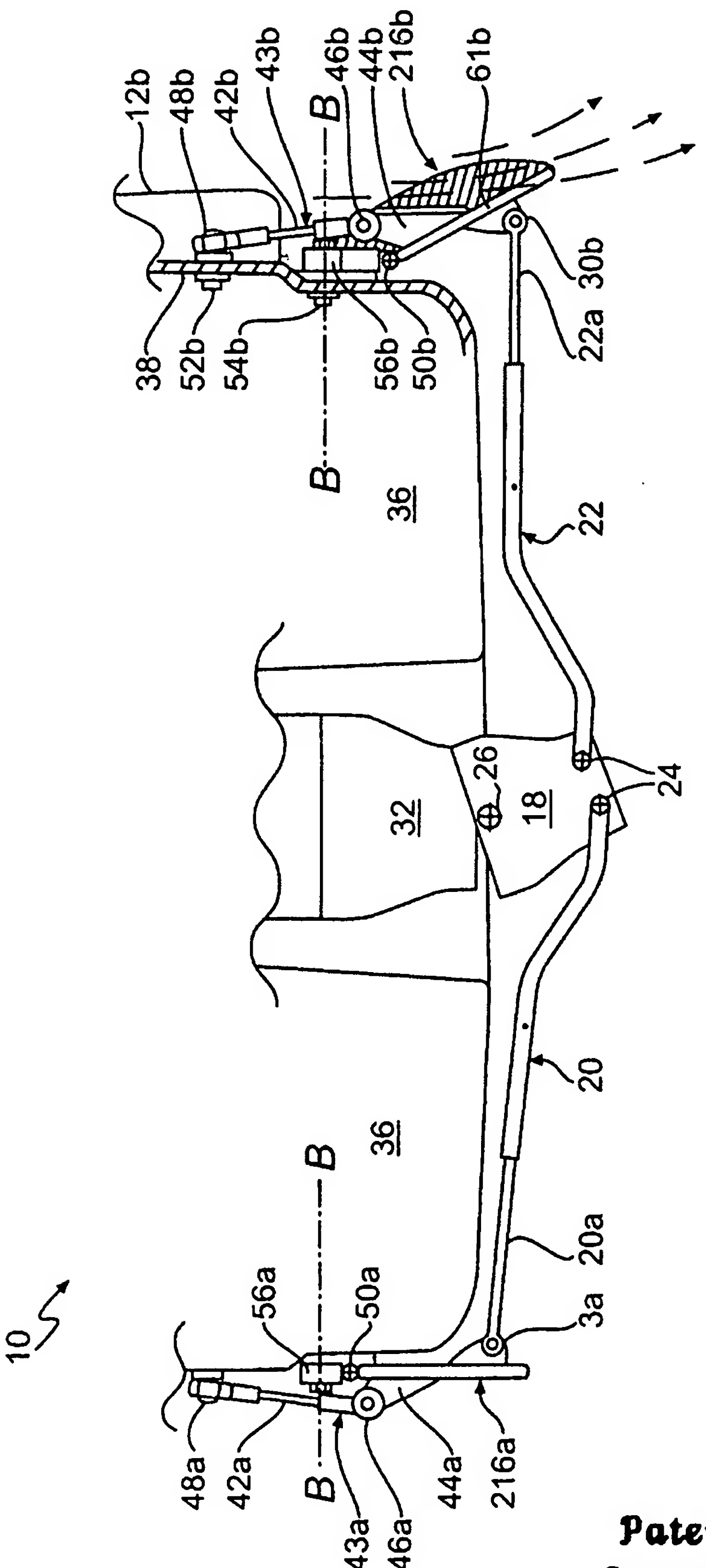
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44b
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B
36
22
32
26
18
24
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B
36
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10
56a
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3a
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42a
B
43a
46a
44a
216a

FIG. 2

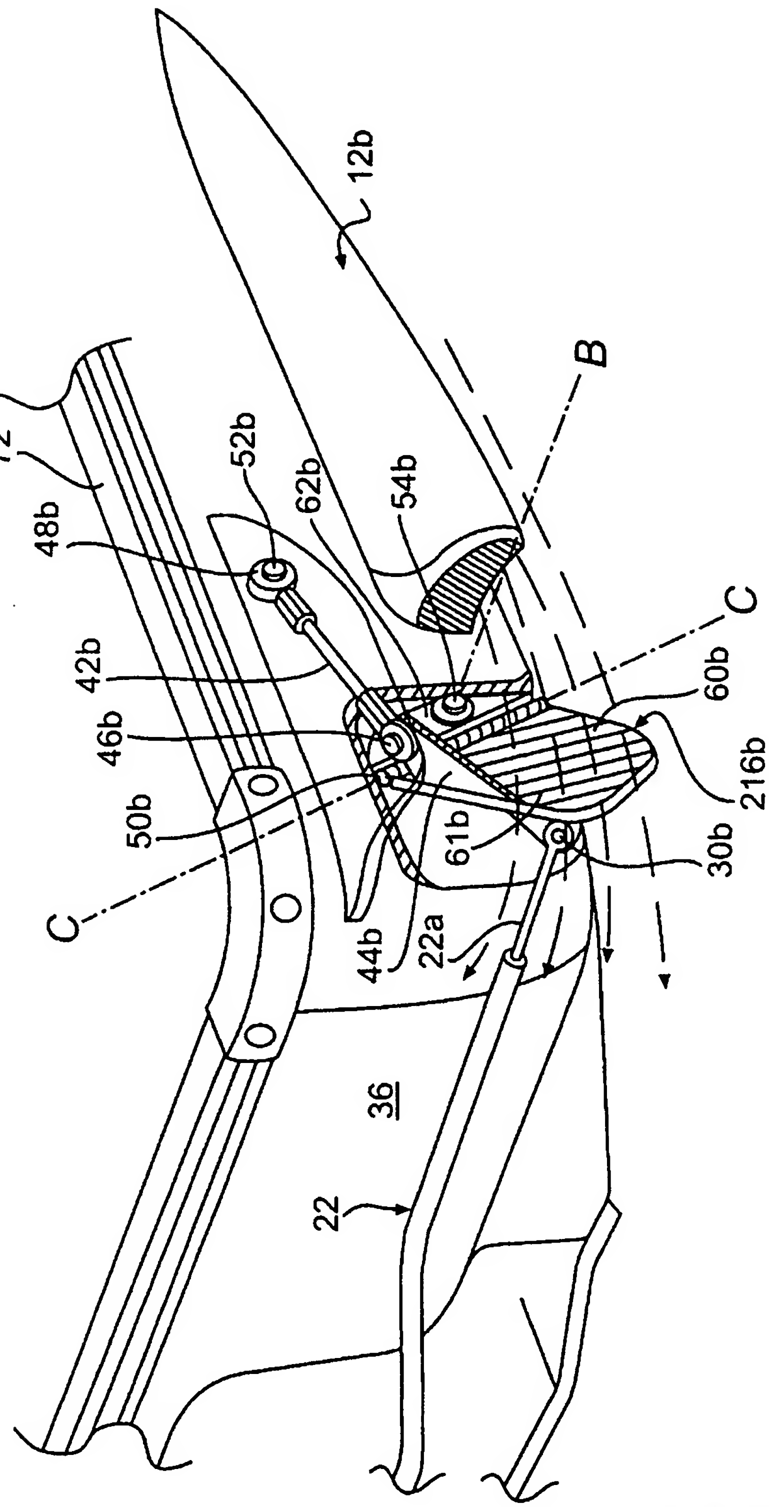

FIG. 3

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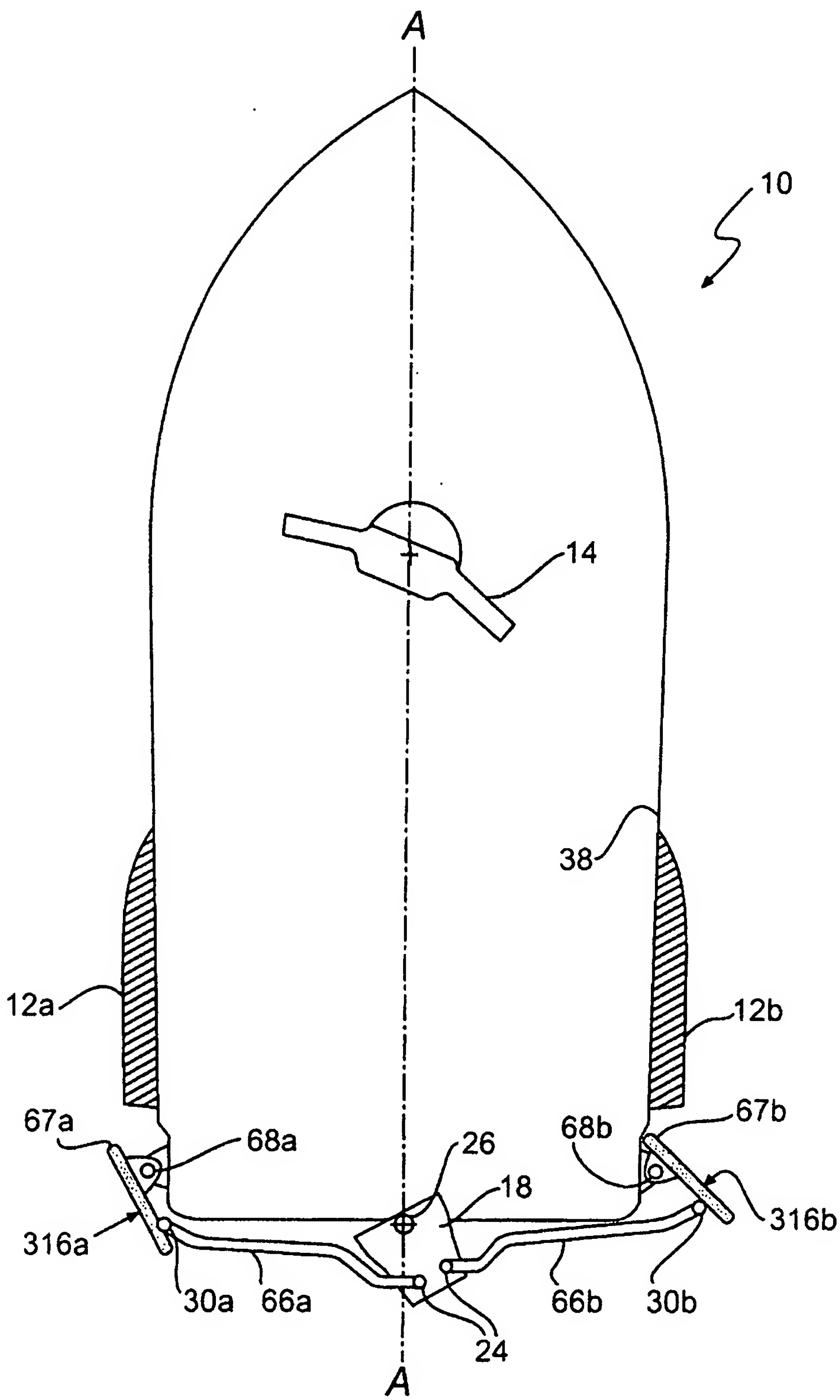

FIG. 4

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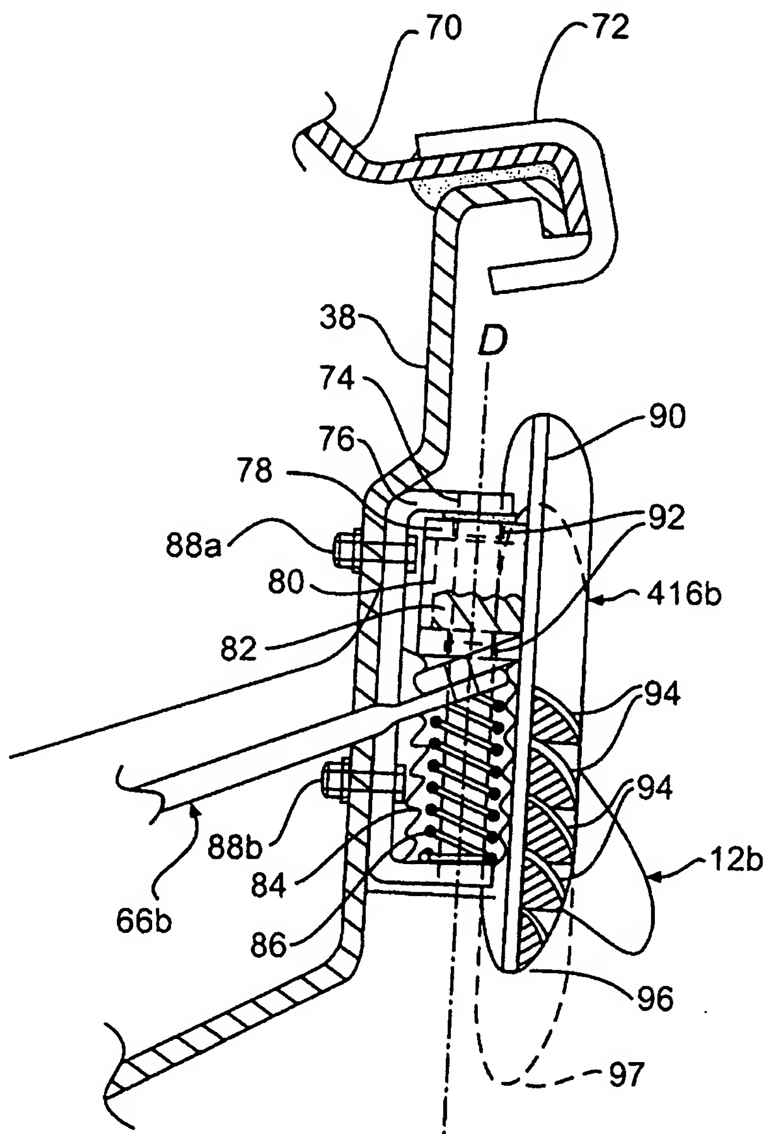

FIG. 5

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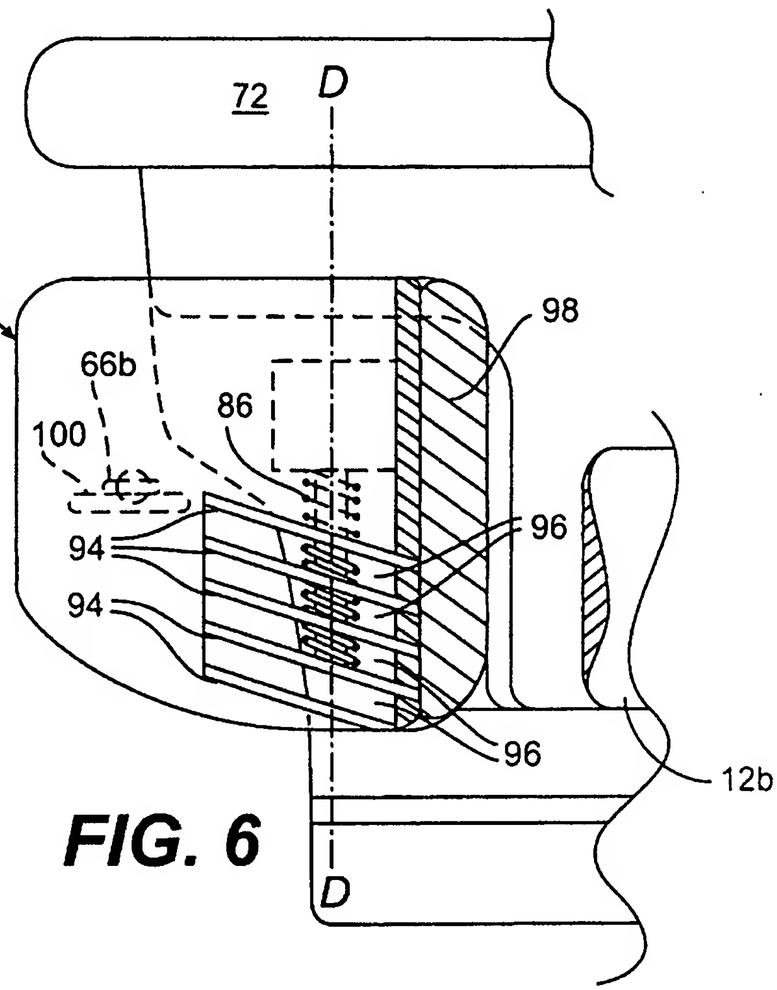

FIG. 6

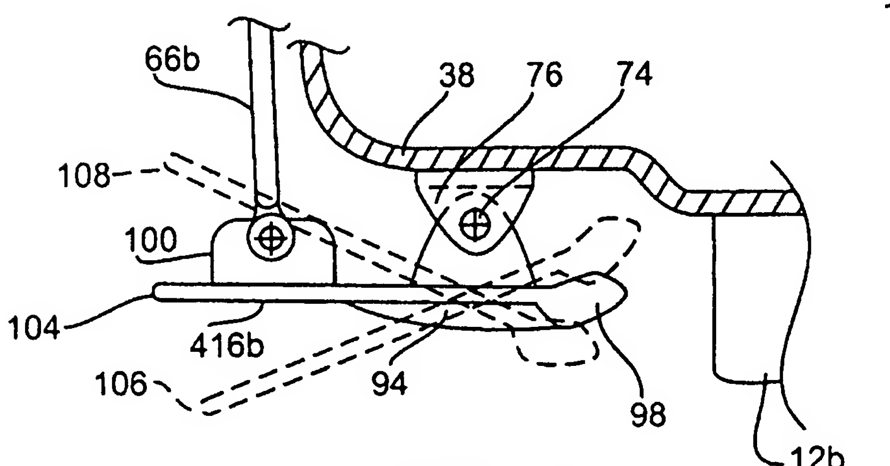

FIG. 7

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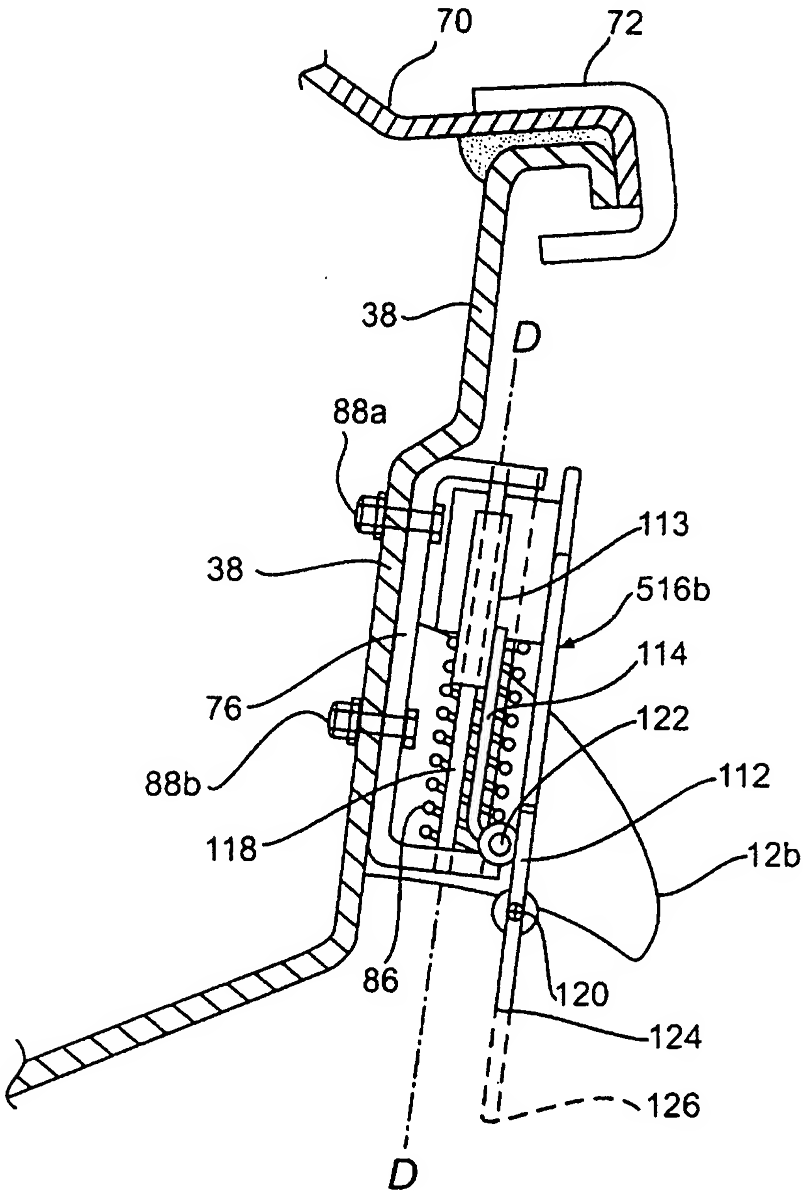
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72
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12b
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124
126
D

FIG. 8

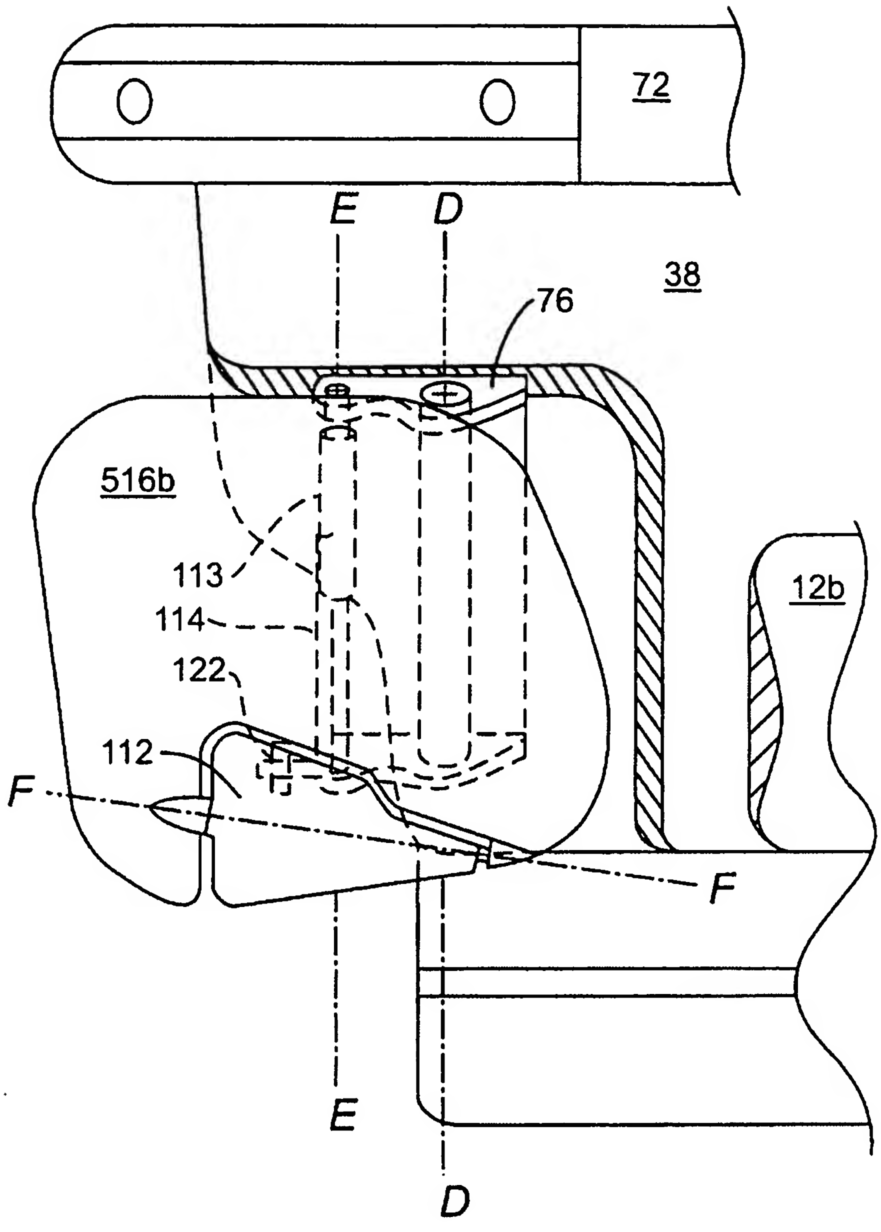

FIG. 9

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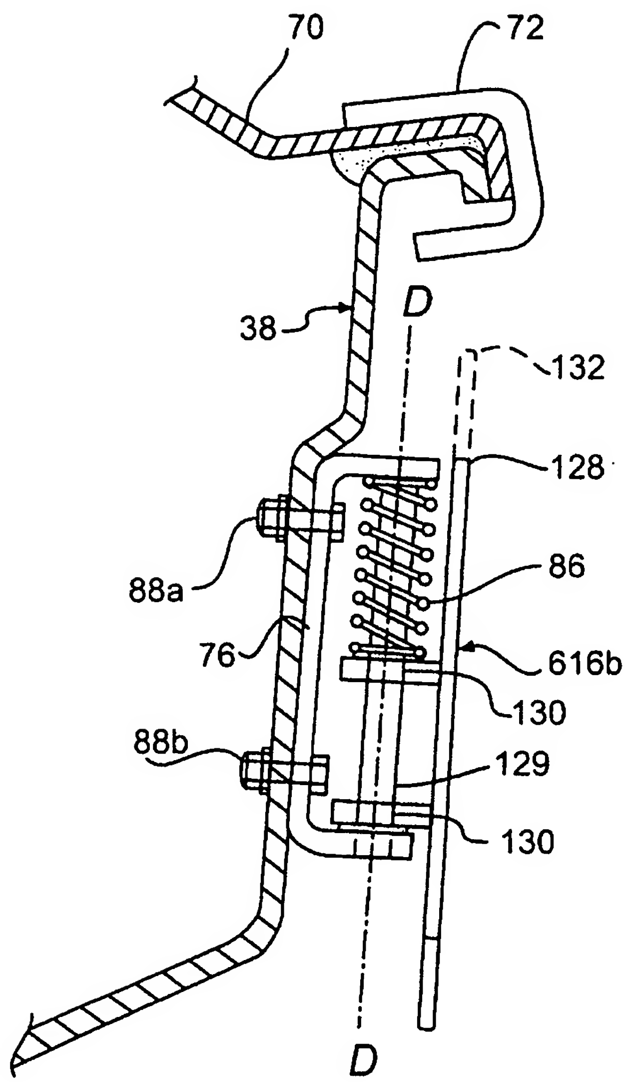

FIG. 10

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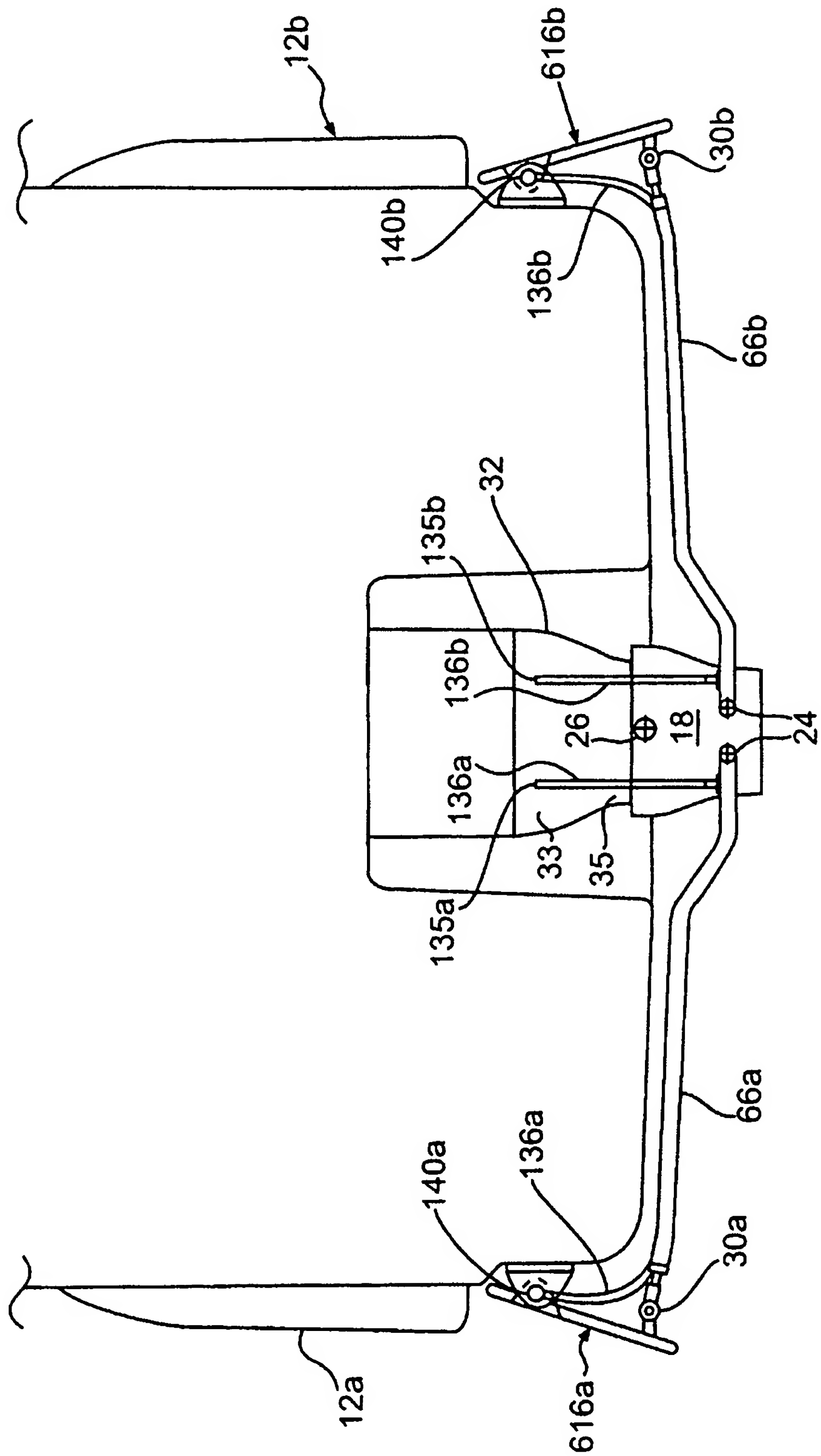
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30a
12a
616a

FIG. 11

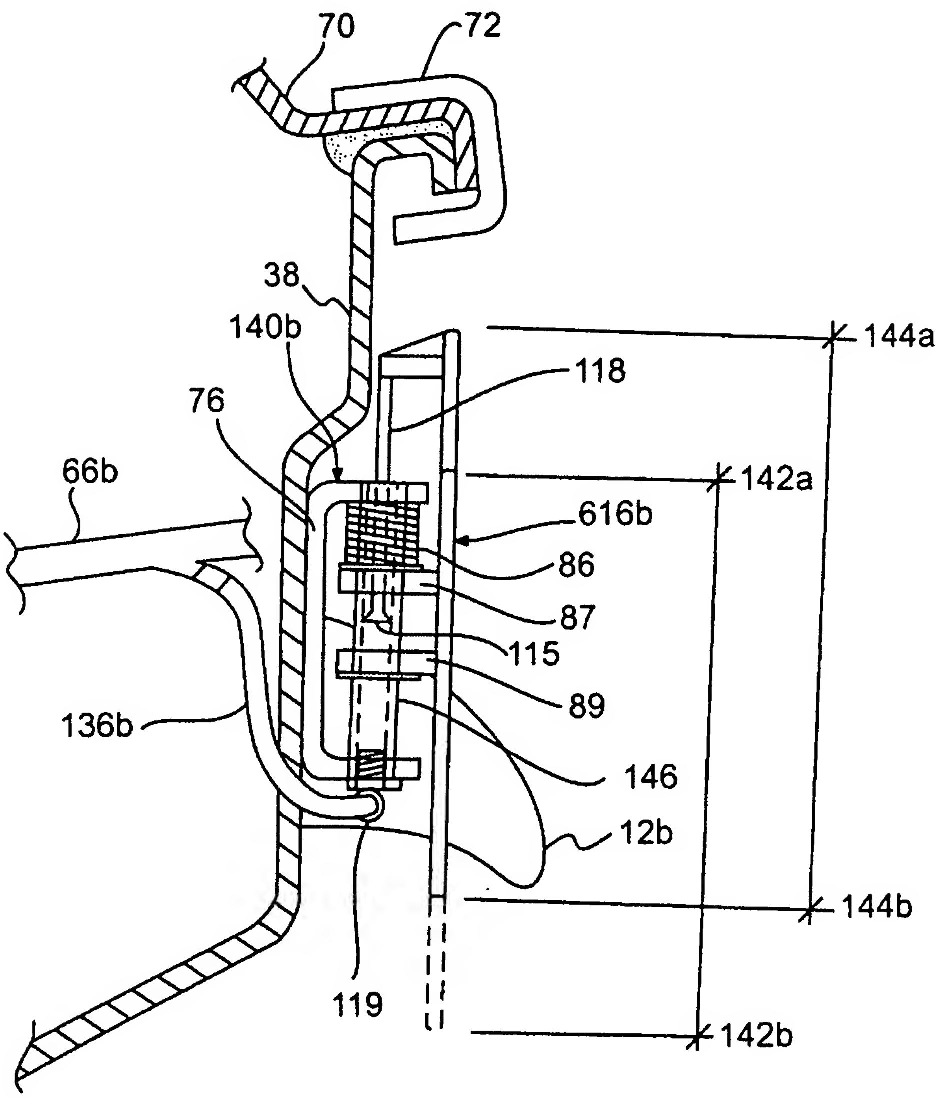
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FIG. 12

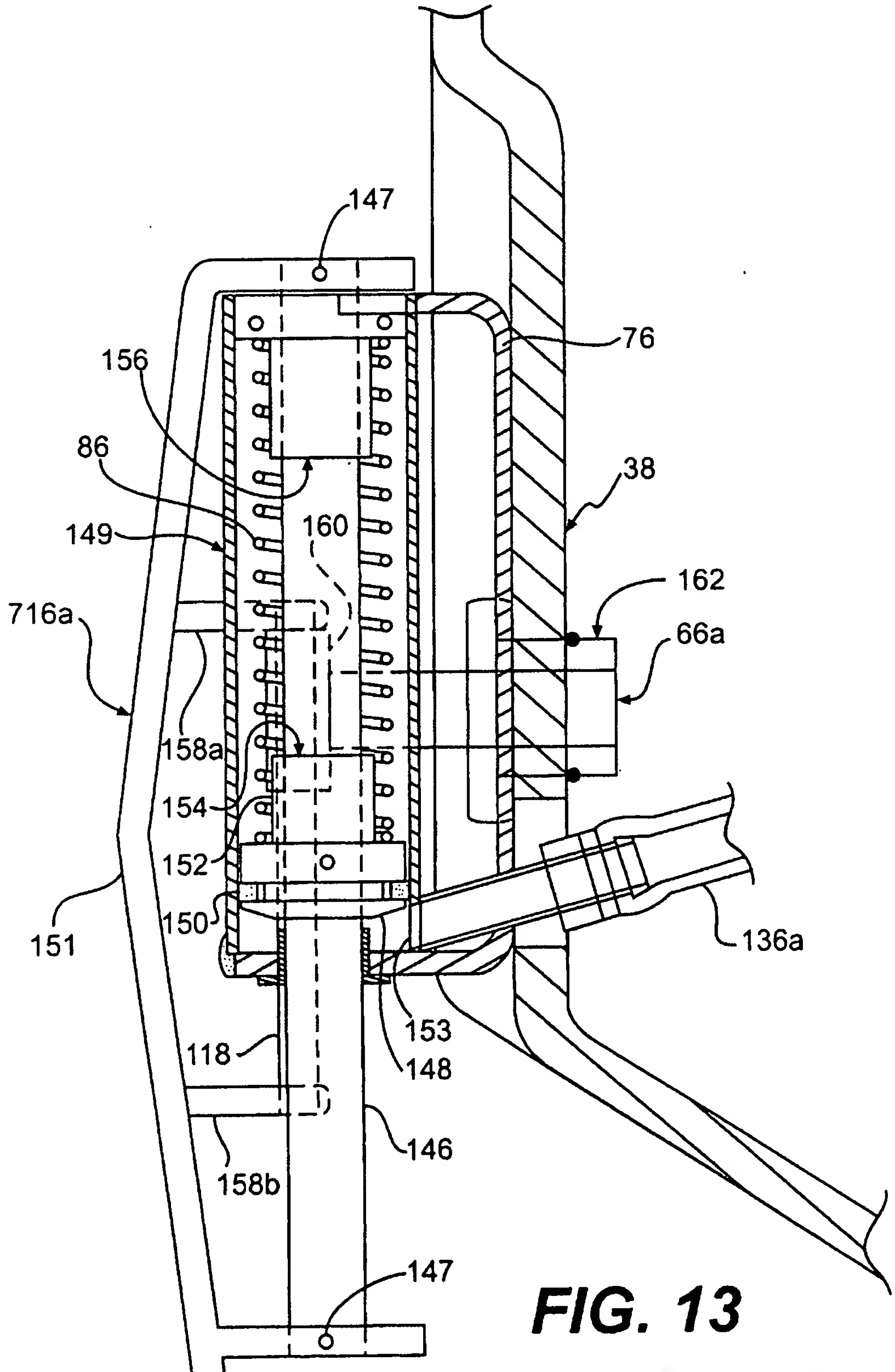

FIG. 13

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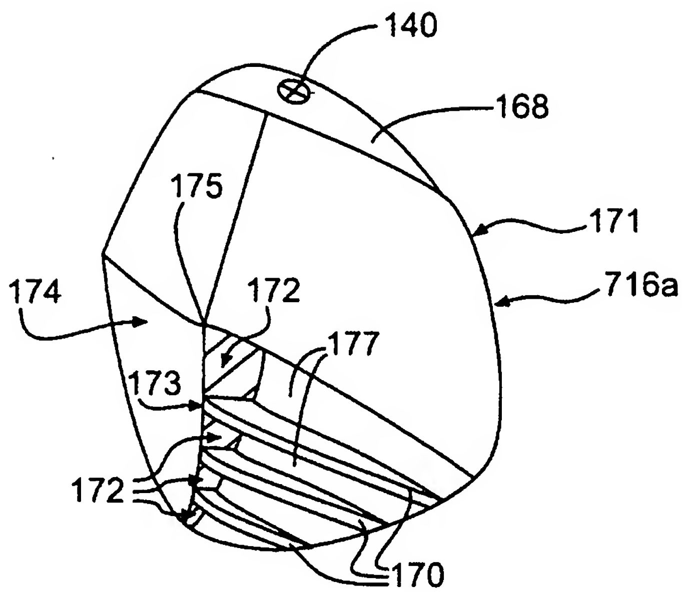

FIG. 14a

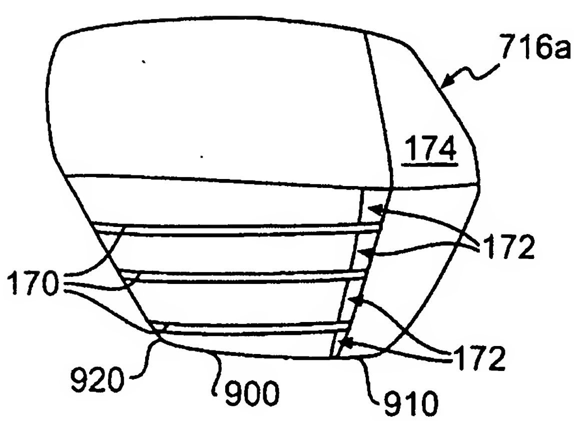

FIG. 14b

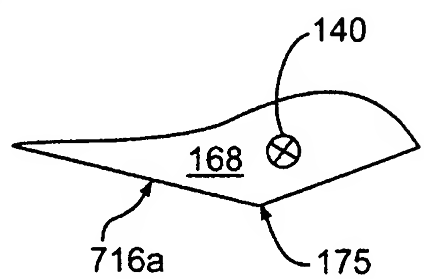

FIG. 14c

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FIG. 15c

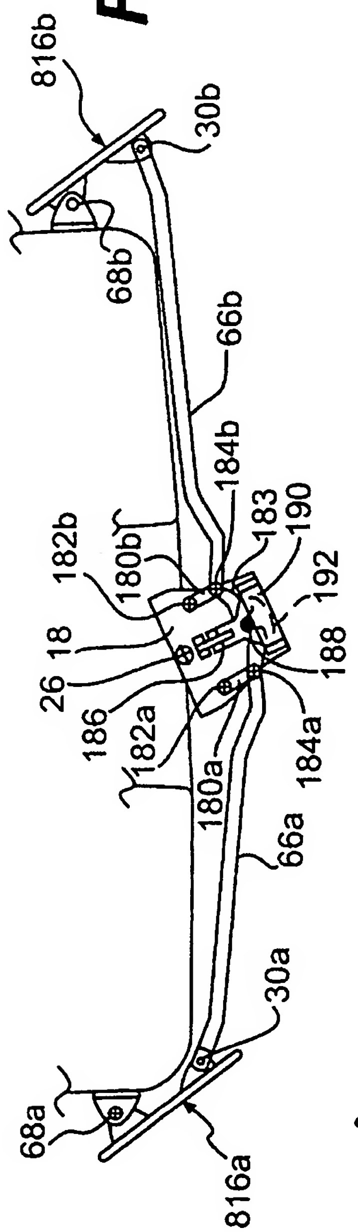


FIG. 15b

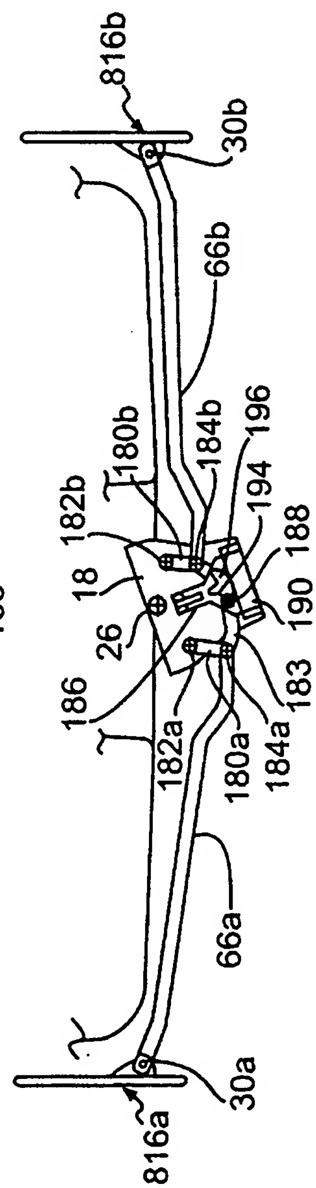
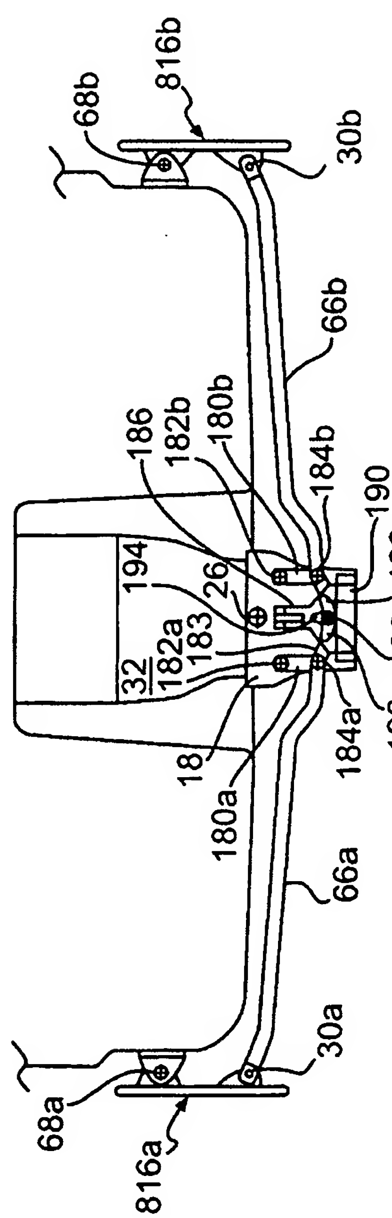
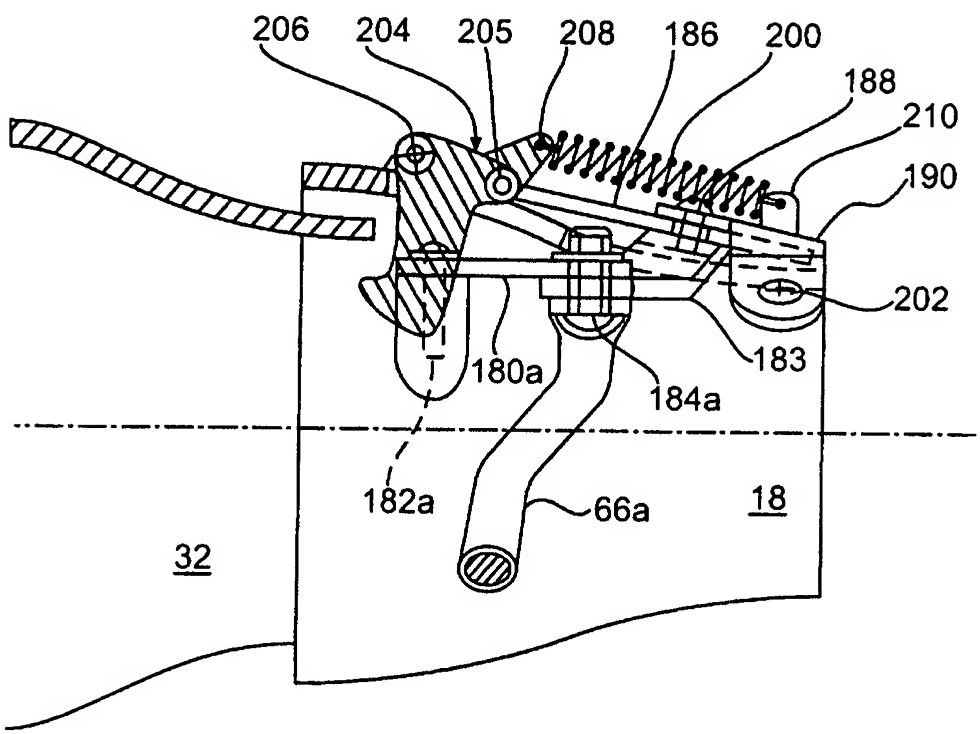


FIG. 15a

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66a
18
32

FIG. 16

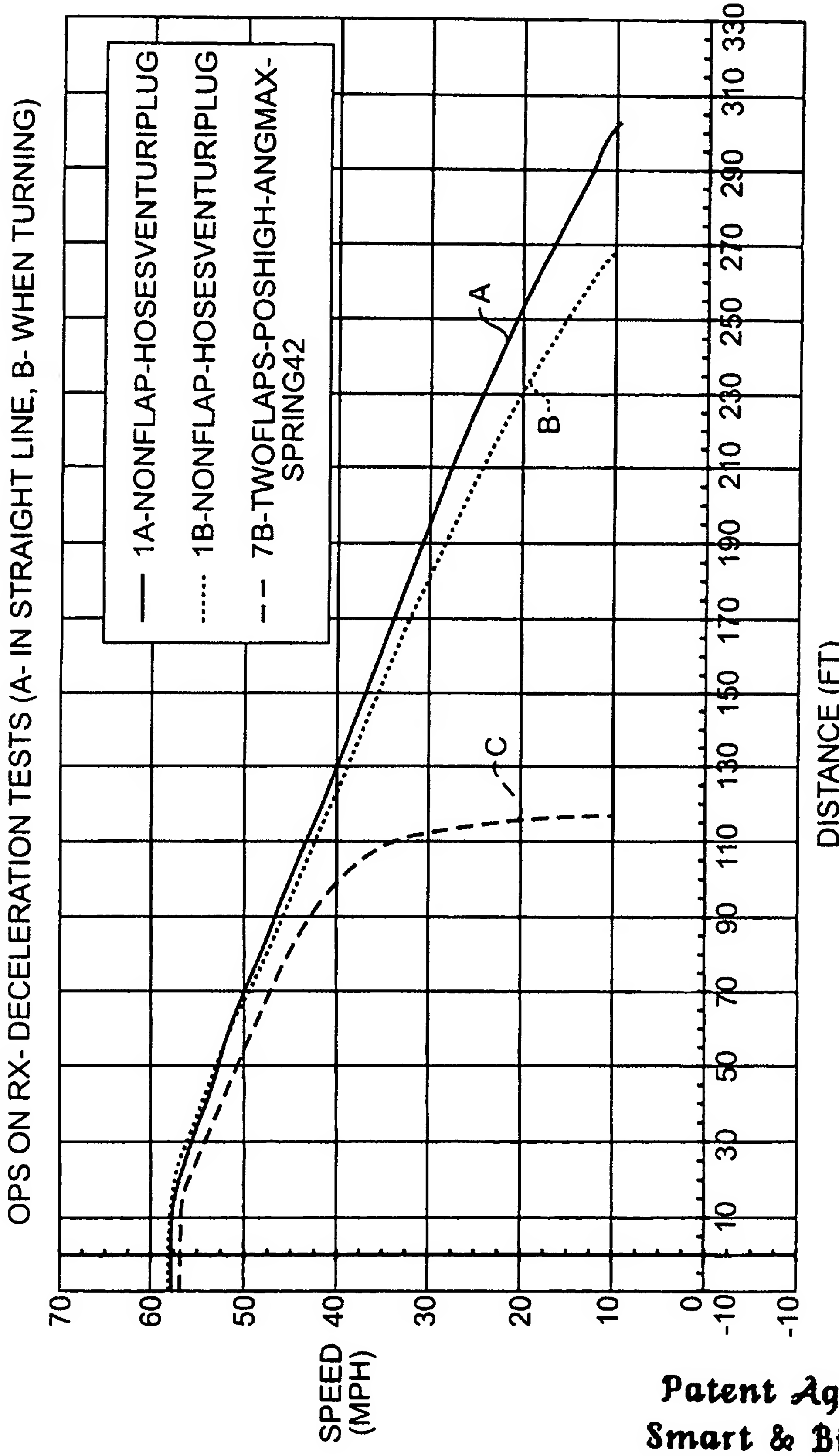

FIG. 17

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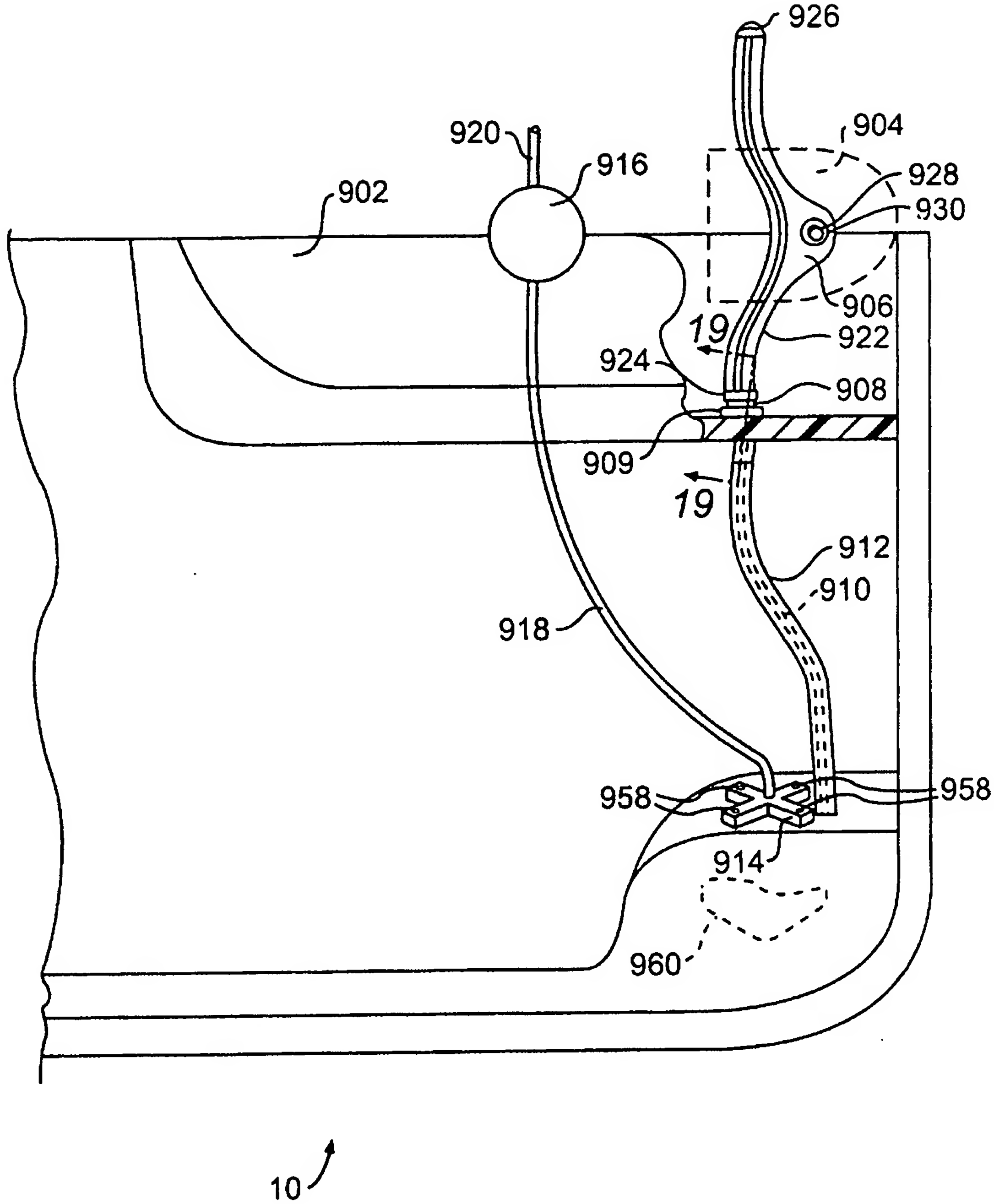

FIG. 18

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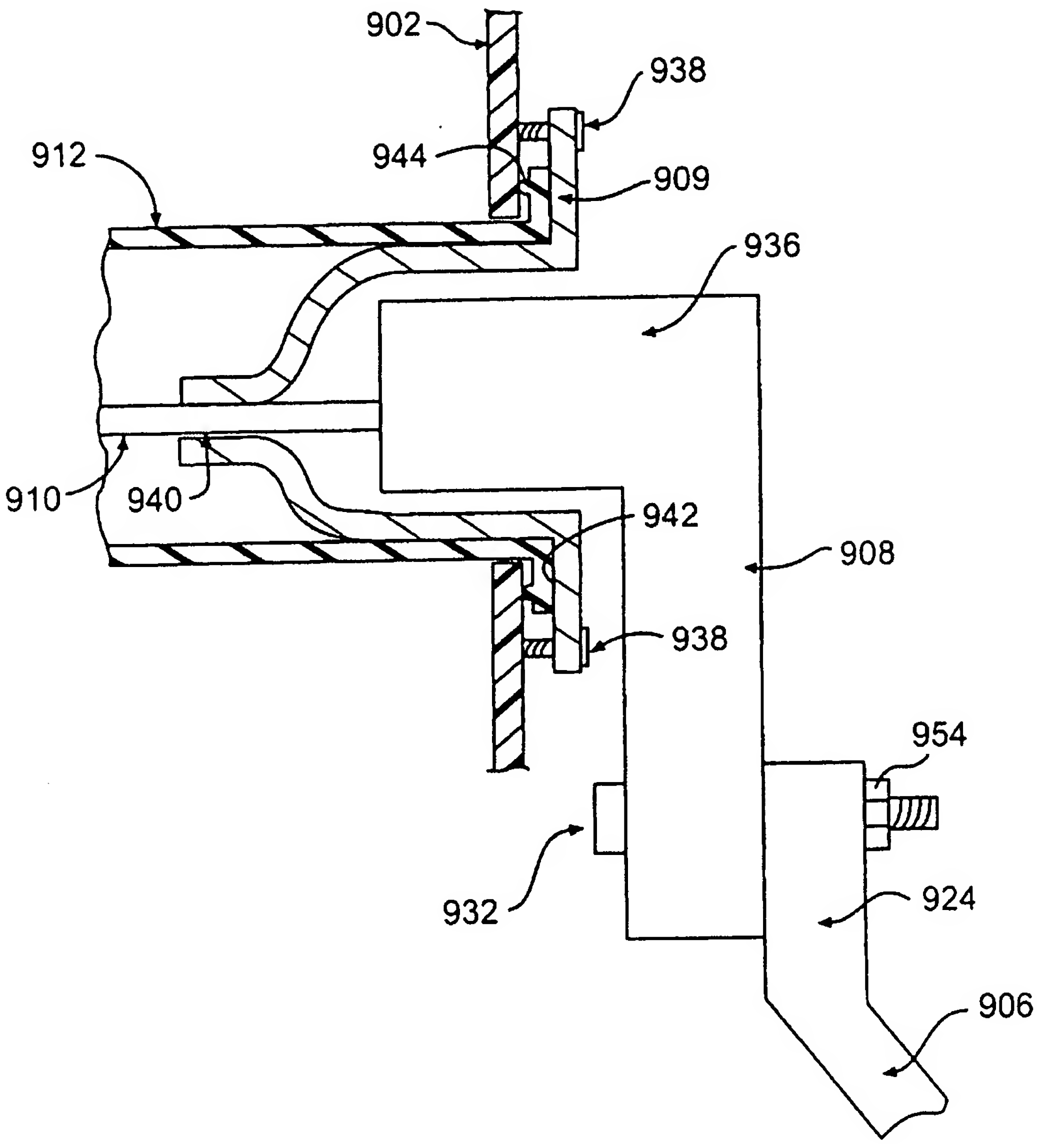

FIG. 19

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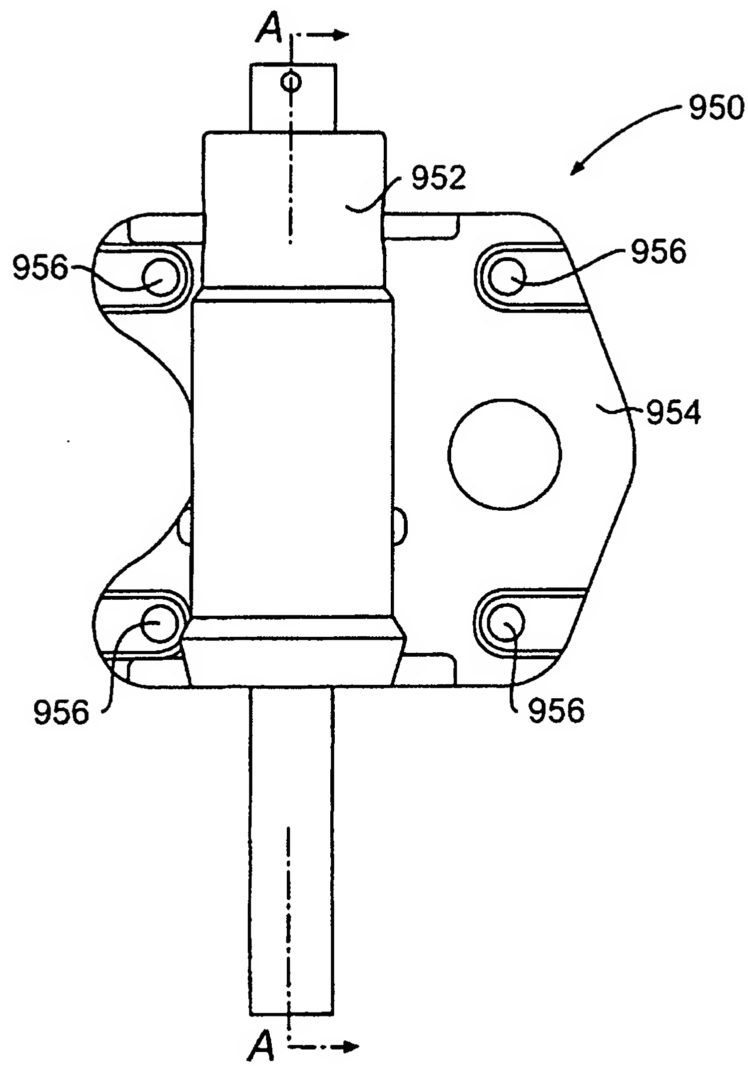

FIG. 20

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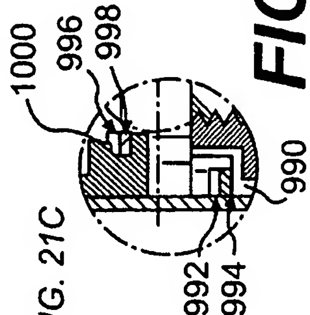

FIG. 21C

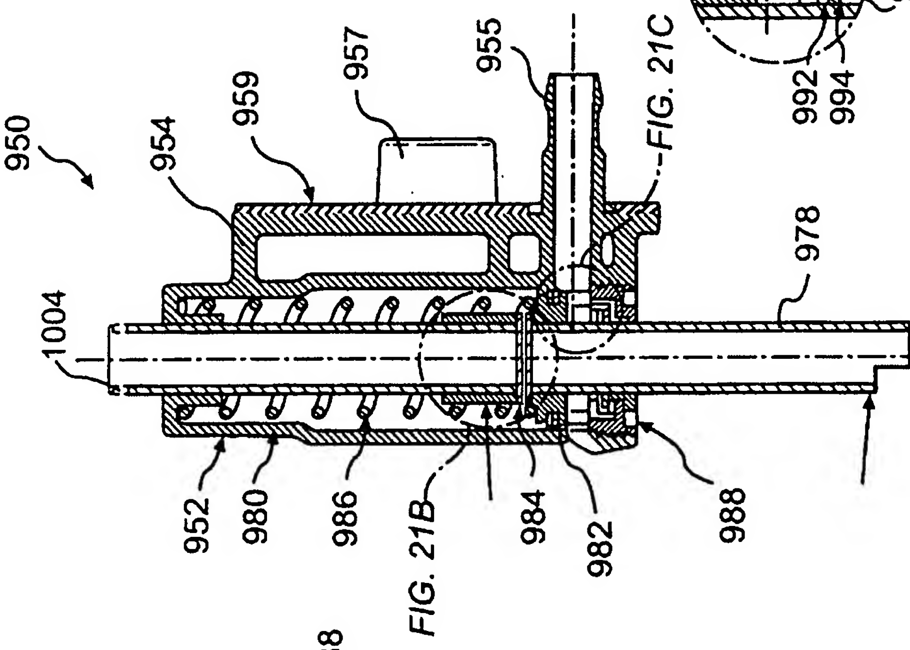

FIG. 21A

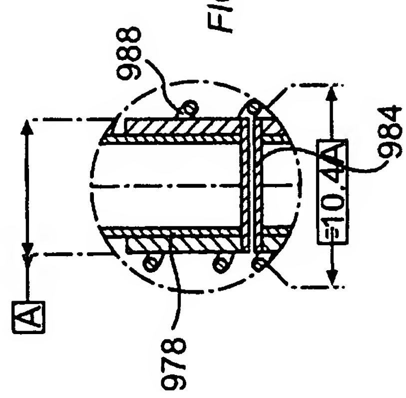

FIG. 21B

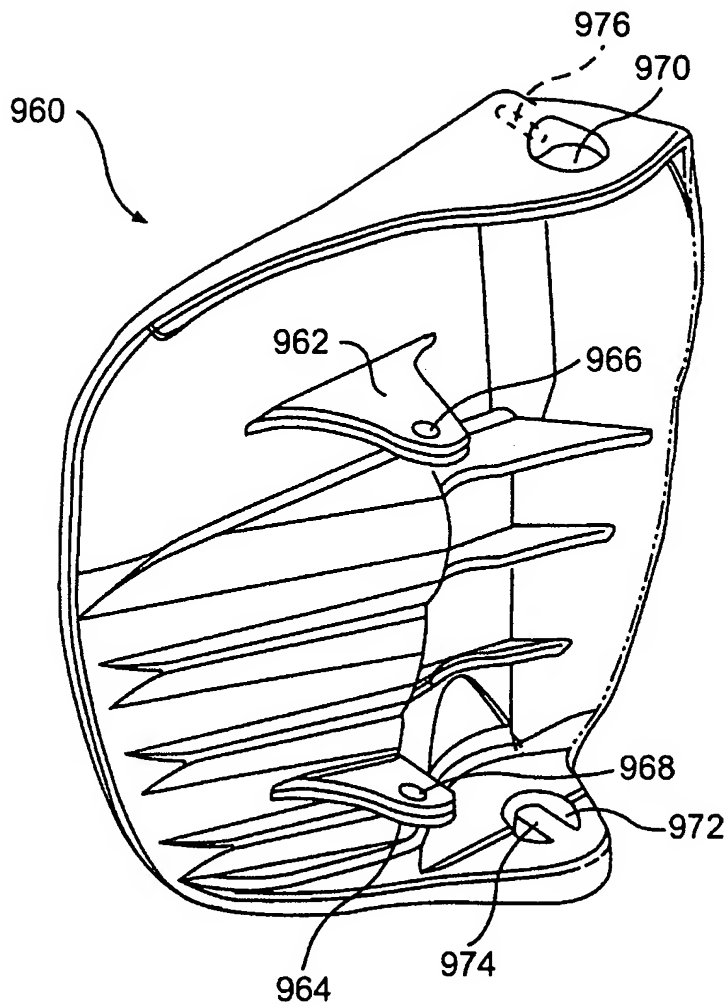

FIG. 22

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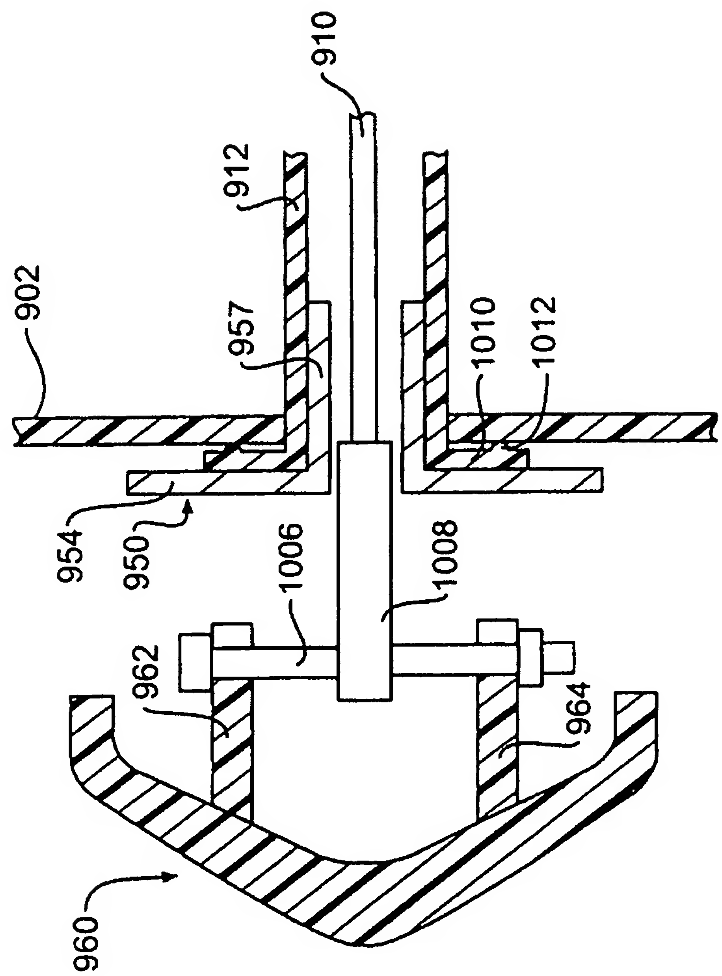
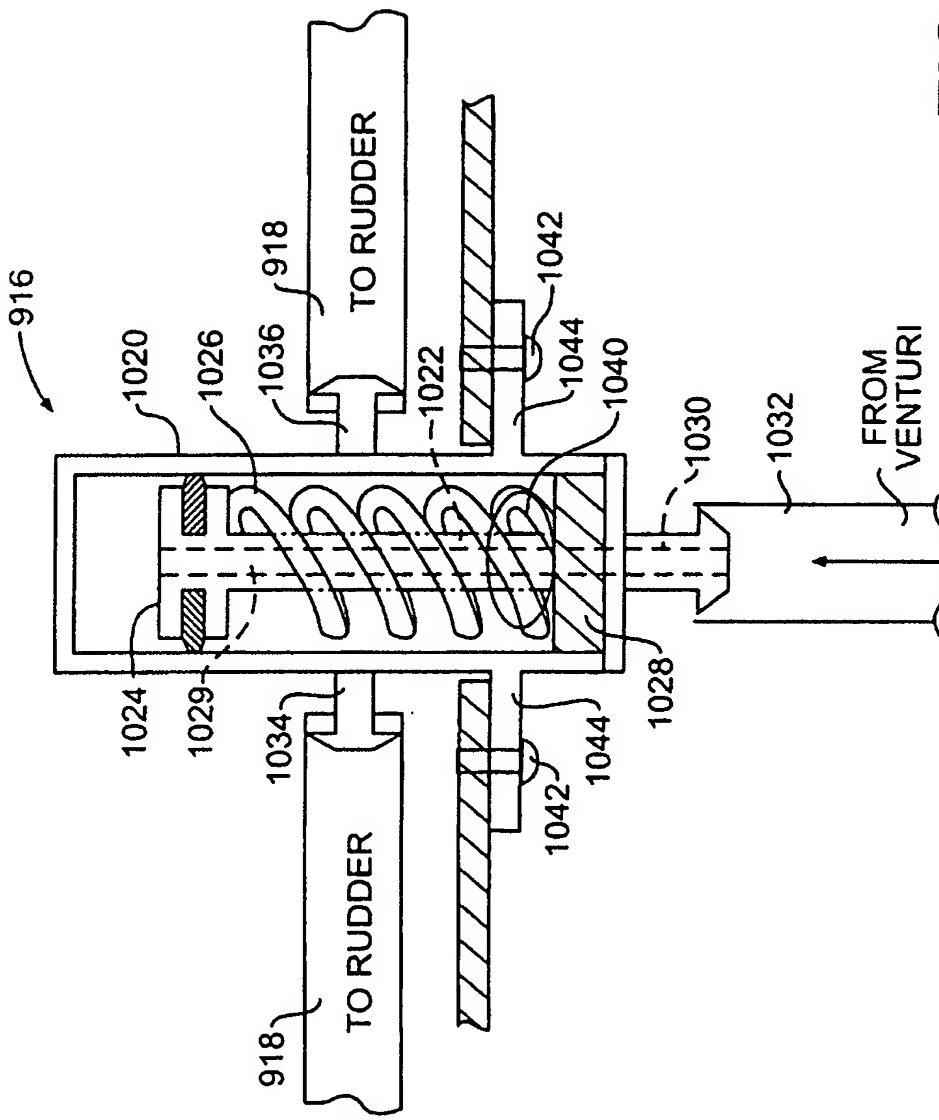


FIG. 23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918
TO RUDDER
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1036
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1032
FROM VENTURI
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1044
1042
1028
TO RUDDER
918

FIG. 24

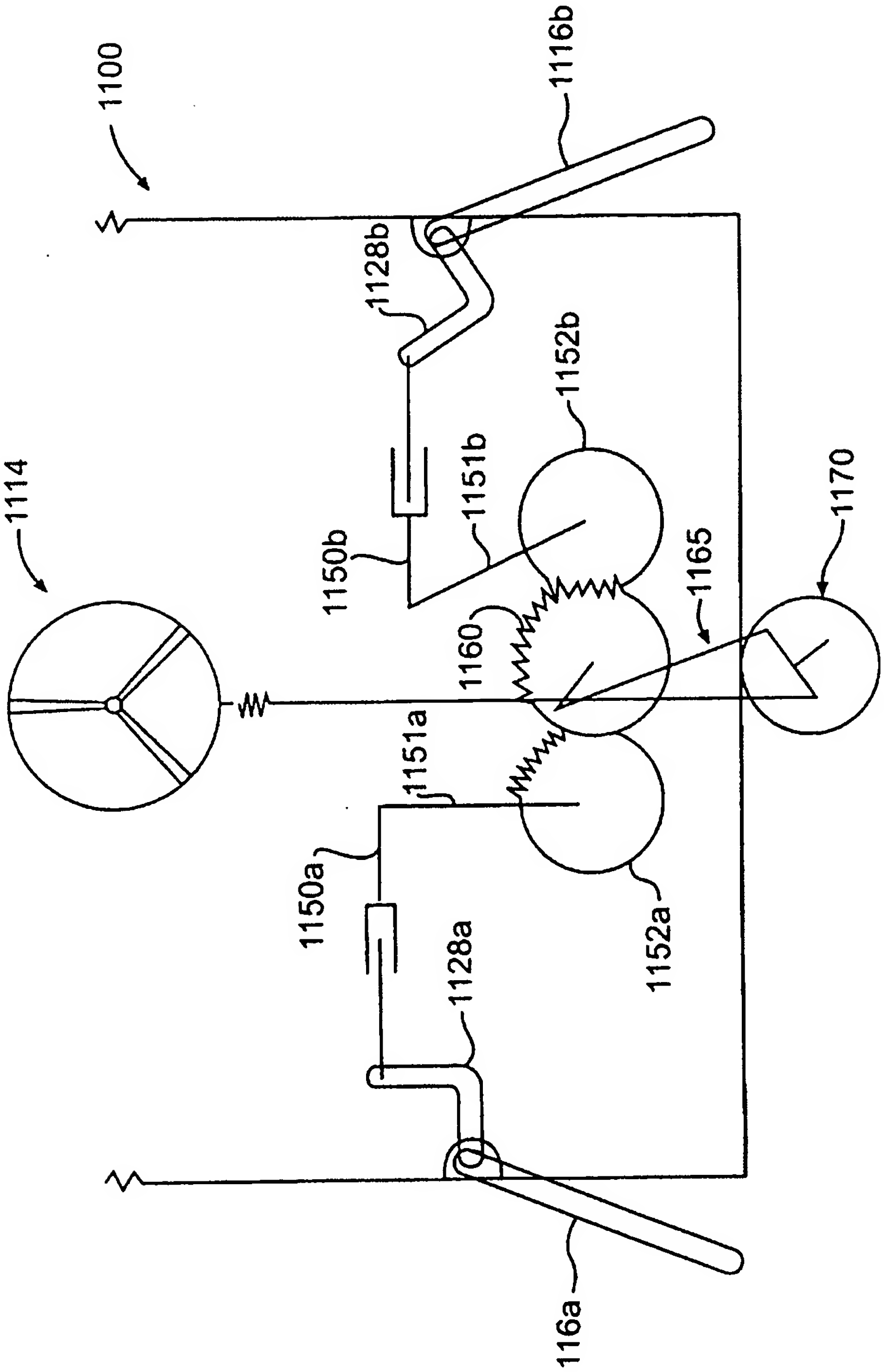

FIG. 25
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